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A Factor Analysis of Physical Fitness Components for Seventh Grade Chinese Students

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A FACTOR ANALYSIS OF PHYSICAL FITNESS COMPONENTS FOR SEVENTH GRADE CHINESE STUDENTS

(TITLE)

BY

Chen-Hsing Huang

THESIS

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
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IN THE GRADUATE SCHOOL, EASTERN ILLINOIS UNIVERSITY
CHARLESTON, ILLINOIS

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A FACTOR ANALYSIS OF PHYSICAL FITNESS COMPONENTS FOR SEVENTH GRADE CHINESE STUDENTS

By

Chen-Hsing Huang

ABSTRACT OF A THESIS

Submitted in partial fulfillment of the requirements
for the degree of Master of Science at the Graduate School
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Charleston, Illinois
1981

A Factor Analysis of Physical Fitness Components for Seventh Grade Chinese Students

ABSTRACT

The main purpose of this study is to explore the basic elements of physical fitness, which can serve as a source for the construction of a physical fitness test for Chinese students. The subjects of this study are 100 male seventh grade students of junior high school in Kaohsiung City, Republic of China.

A physical fitness test consisting of 29 subtests was devised and used as the basis for the investigation. Data collected from tests were analyzed by means of factor analysis and resulting in the following:

I. Seven basic elements that account for physical fitness were found. They were speed-explosive strength, the size of the body, endurance, coordination, strength of body muscle, flexibility, and dynamic flexibility-dynamic strength. These seven factors accounted for 70% of the total variance of physical fitness.

II. Items in the physical fitness test which correspond to factors were given below:

1. Speed-explosive strength factor - 100, 40, 80, 60, and 50 meter dashes, standing long jump, shuttle run and vertical jump.

2. The size of the body factor - weight, height, grip strength, chest girth, softball throw for accuracy, handball throw for distance.

3. Endurance factor - 1000, 1200 and 800 meter run.

4. Coordination factor - standing triple jump, softball throw for distance.

5. Strength of body muscle factor - sit-ups for 1 minute, sit-ups for 30 seconds.

6. Flexibility factor - side-steps, trunk extension backward, zig-zag run.

7. Dynamic flexibility-dynamic strength factor - trunk extension forward, push-ups, pull-ups.

According to the investigation described above, each of the seven basic elements of physical fitness was virtually independent. When high scores on certain fitness measures are found but are not found on other measures, we, therefore, cannot assume there is a "general physical fitness" criteria.

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CHAPTER I

INTRODUCTION

Scholars of other countries have recognized the importance of physical fitness and have investigated the structure of fitness much earlier than the Chinese. As a result, a considerable amount of research has been done on the structural elements as well as the development and administration of testing physical fitness. In contrast, the Chinese have done little in this respect because the establishment of research institutes of physical education developed later than other countries and due attention was not given. Consequently, the Chinese need to promote more research in physical education and especially in the area of fitness.

Statement of the Problem

The purpose of this study was to determine by factor analysis the common factors of physical fitness for seventh grade junior high school male students in the Republic of China.

Statement of Hypotheses

According to the objectives of this study and on the basis of the available literature, the following hypotheses

were constructed:

1) Data from the 29 subtests of physical fitness will yield by means of a factor analysis seven common factors, which will account for 70 percent of variance of the total test.

2) The subtests that may be related to a common factor are as follows:

1. Factor P_1 - Includes the 40, 50, 60, 80, and 100 meter dashes, shuttle run, vertical jump, standing long jump, and a triple jump.
2. Factor P_2 - Includes the 800, 1000, and the 1200 meter runs.
3. Factor P_3 - Includes sit-ups for 30 seconds and sit-ups for one minute.
4. Factor P_4 - Includes push-ups, pull-ups, and forward trunk extension.
5. Factor P_5 - Includes the handball throw for distance, shot-put, baseball throw for accuracy, and softball throw for accuracy.
6. Factor P_6 - Includes the height, weight, chest girth, and grip strength.
7. Factor P_7 - Includes side stepping, zig-zag run, and backward trunk extension.

Need for the Study

Chi-Yong Yang (38:43-59), an educator, conducted a comparative study of the differences in physical fitness among Chinese, American, and Japanese students. The results showed that physical fitness of the Chinese students was far below that of American and Japanese. Obviously, the problem of physical fitness among Chinese students should no longer be overlooked and a physical fitness test appropriate for the Chinese should be developed. Chinese studies in the field of physical education have not been well developed and the methods that investigators employed have been outdated resulting in a lack of emphasis on fitness.

Chinese understanding of the structure and assessment of physical fitness was developed mainly from the literature published in other countries. However, it has become evident that the suitability of the research in other countries was limited due to the differences in the Chinese culture, environment, and possibly the anatomical differences of the people.

The Chinese need to determine the components of physical fitness as they relate specifically to the Chinese population. A modern Chinese physical fitness test needs to be developed so standards can be established relevant to the Chinese.

Definition of Terms

The following terms have been defined as they were used

in this study:

Physical fitness test scores

The physical fitness test scores of the first year male students of Jui-Fong Junior High School and Kuang-Hua Junior High School were obtained from 29 subtests.

Structure of physical fitness

Those common factors extracted from the test items of physical fitness through factor analysis.

Limitation of Study

The study was limited to a small sample of male students of the seventh grade of schools in Kaohsiung City, Taiwan, Republic of China. Kaohsiung is a densely populated area of 1,200,000 people. The sample may be representative of the seventh grade students in Kaohsiung but may not represent the whole of Taiwan since smaller communities and several rural areas were not included in the study.

CHAPTER II

REVIEW OF RELATED LITERATURE

This study relating to the components of the physical fitness of Chinese children, was an attempt to improve an understanding of physical fitness as it relates to the Chinese. This chapter reviews the structure of physical fitness, physical tasks developed in various countries, including the Republic of China and the application of factor analytic studies

Larson and Yocom's Structure of Physical Fitness

Larson and Yocom (22:154-164) illustrated the structure of physical fitness as shown in Figure 1. They present the structure of physical fitness in the form of a staircase and each level serves as the basis for the one above.

Larson and Yocom consider the structure and function of the body to be basic to the development of skills. The next level includes basic components such as strength, flexibility, agility, and endurance which serves as the basis to the formation of athletic skills such as dribbling, passing and shooting.

T. K. Cureton's Structure of Athletic Ability

Cureton (12:18-25) established a different view from that of Larson and Yocom. Cureton diagrammatized the structure of athletic ability as shown in Figure 2. Cureton attempted to define physical fitness as bodily strength. With this in view, he analyzed the structure of athletic ability by dividing the range that man adapts himself to his surroundings into the following four categories; physical fitness, emotional fitness, conscious fitness, and social fitness. Figure 1 illustrates that Cureton divided physical fitness into five areas, namely, the state of organs, physique, motor fitness, sense organ fitness, and athletic skill. Furthermore, motor fitness was broken down into components, such as equilibrium flexibility, agility, muscular strength, power, and endurance. These were considered by Cureton to be important aspects of athletic ability.

The difference between Cureton's and Larson and Yocom's structure is that Cureton did not specify those fundamental abilities such as running, jumping and throwing. Instead, he placed emphasis on fitness of the sense organs, which served as the basis of athletic skills.

University of California Physical Efficiency Test

The University of California Physical Efficiency Test (37:151-154) was constructed in accordance with the analysis of the physical ability required in social fitness. According

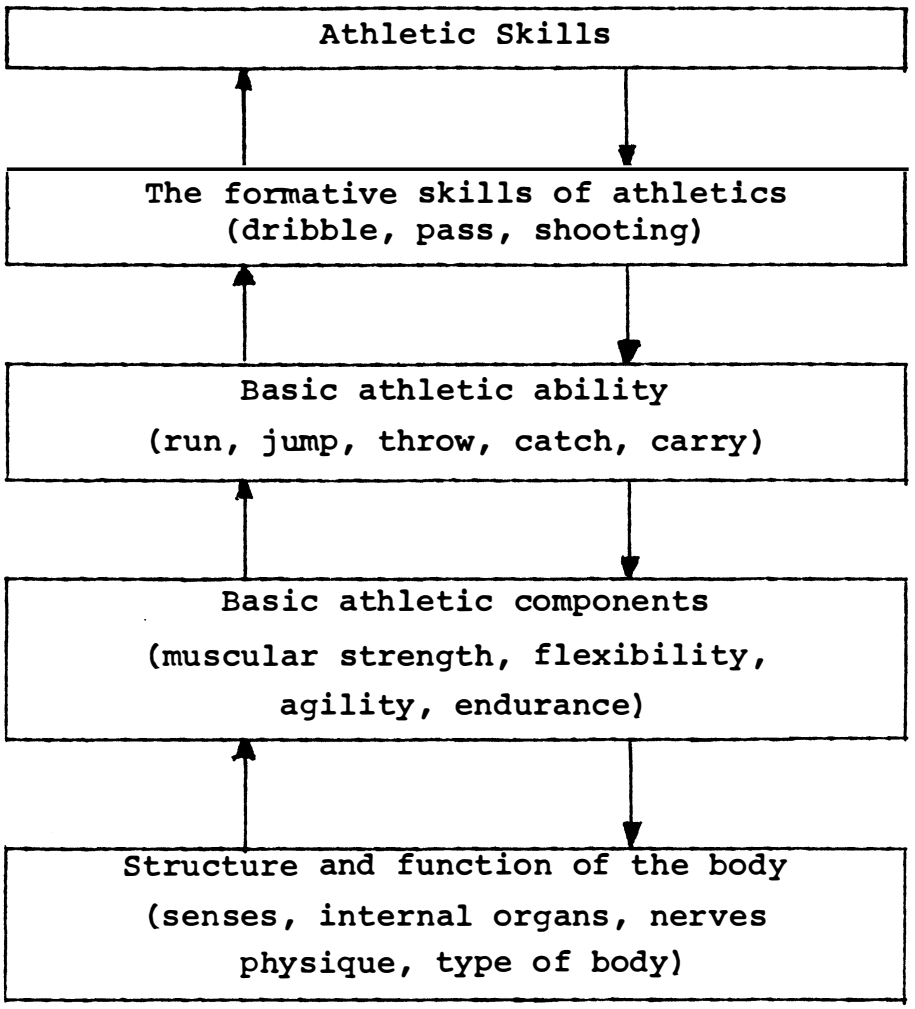

Figure 2-1

Diagram of Larson and Yocom's
Structure of Physical Fitness (1951)

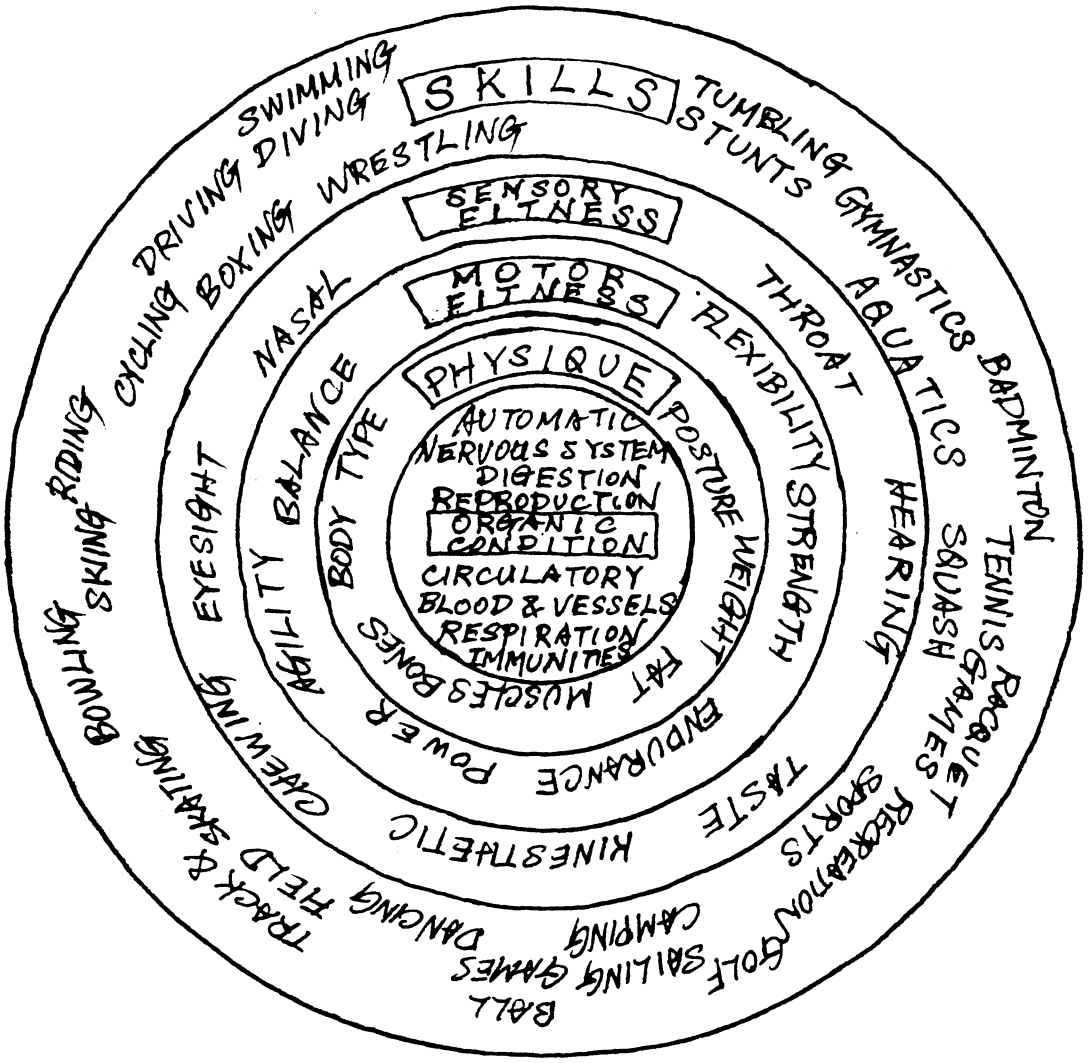

Figure 2-2

T. K. Cureton's Structure of Bodily Strength

to its analysis, physical fitness included the following athletic abilities:

(1) Running
(2) Jumping
(3) Throwing
(4) Pierce
(5) Kicking
(6) Pushing
(7) Pulling
(8) Sudden shift of direction
(9) Coordination of eyes and hands with object
(10) Strength of abdominal muscle and strength of back muscles
(11) Equilibrium
(12) Ability to get over obstacles quickly
(13) Ability to carry quickly
(14) Ability to control the body quickly while in the air or in motion
(15) Ability to control the body when hanging with the arms and trying to move, or when jumping up and touching a position with the hands.

F. W. Cozens' Basic Athletic Ability

Cozens (5:45-52) synthesized the findings of many authors and listed the following seven items as the basic athletic ability of various kinds of sport and contest.

(1) The muscular strength of arm and shoulder (pull-up, push-up on parallel bar).

(2) Coordination of the arm and shoulder (various kinds of throwing).

(3) Coordination of hand and eye, foot and eye, and of arm and eye (passing ball or kicking ball).

(4) Leaping, muscular strength of foot and flexibility (standing long jump).

(5) Endurance (long distance run, etc.).

(6) Bodily adjustment, agility, and control (zig-zag run).

(7) Feet speed.

The Application of Factor Analysis

As early as 1934, American scholars in the field of physical education began to use the factor analysis. This is a statistical technique usually utilized in the analysis of intelligence and personality but has also been used to analyze physical fitness. By 1950, there were approximately thirty similar research reports (37:147-149). In this technique, the first step is to determine the scope of physical fitness and then to analyze the independent factors involved. Because investigators took different views as to the scope of physical fitness, their findings were somewhat different. Certain researchers have completed significant studies and identified specific components as follows:

(1) C. H. McCloy:

a. muscular strength

b. speed

c. coordination of large muscles

(2) L. M. Jones:

a. coordination of large muscles

b. size of body

(3) E. McCloy:

a. muscular strength

b. speed

c. weight

(4) A. J. Wendler:

a. muscular strength

b. speed

c. ability to learn sports

d. feelings - athletic coordination

(5) L. M. Roulhac:

a. speed

b. coordination

c. endurance

d. weight

(6) L. A. Larson:

a. dynamic muscle

b. muscular strength measured by dynamometer

c. coordination of large muscles

d. strength of abdominal muscle

(7) T. K. Cureton:

a. equilibrium

b. flexibility

c. muscular strength

d. power

e. agility

f. endurance

Factor analytic studies in the United States have provided six independent factors with a frequency of five occurrences or more. These factors and frequencies are shown below.

Independent Factors	Frequency
(1) Muscular strength	19
(2) Speed	10
(3) Dead weight	8
(4) Coordination of large muscles	6
(5) Ability to learn sports	6
(6) Dynamic muscular strength	5

Japanese Athletic Ability Test and Diagnostic Test of Bodily Strength

In Japan, the test items most frequently used for measuring the basic athletic abilities are running, jumping, throwing, pull-ups, and the six factors that Cureton suggested (equilibrium, flexibility, muscular strength, agility, power, and endurance). Based on this framework, the Japanese Ministry of Education (37:151-154) constructed its own

athletic test. The basic athletic abilities, mentioned above, were designated as the Athletic Ability Test, whereas Cureton's factors were collectively known as the Diagnostic Test of Bodily Strength. Obviously, the Japanese Structure of Physical Fitness has not departed materially from Cureton's domain.

Chinese Ministry of Education's Physical Fitness Test

The Department of Physical Education, Ministry of Education (29:3-5) constructed in 1976, The Physical Fitness Test for Children and Youth in the Republic of China (29:30-35). This test was the first of its kind in the Republic of China, and its construction was somewhat objective. The procedures used for the construction of the test were described as follows:

A. Twenty-four items were selected and they were classified into nine factors with each factor representing one function. The factor and the included items are presented below:
   1. Speed - 40, 50, 60, 80, and 100 meter dashes. (Items 1-5)
   2. Flexibility - Trunk extension backward and trunk extension forward. (Items 6-7)
   3. Endurance: (2 items for 3 levels of school as follows) (Items 8-9)

Senior High School		Junior High School		Elementary School	
Boy	Girl	Boy	Girl	Boy	Girl
1000m	800m	800m	800m	600m	600m
1200m	1000m	1000m	1000m	800m	800m

4. Agility - shuttle run, side-step, and zig-zag run. (Items 10, 11, 12)
5. Strength of upper extremity - grip strength, push-ups, pull-ups (for girls, flexed arm hang). (Items 13, 14, 15)
6. Strength of trunk: sit-ups for 30 seconds and sit-ups for one minute. (Items 16-17)
7. Power - vertical jump, standing long jump, and triple jump. (Items 18, 19, 20)
8. Coordination: Softball throw for distance and handball throw for distance. (Items 21-22)
9. Accuracy - Baseball throw for accuracy and softball throw for accuracy. (Items 23-24)

B. The foregoing test items were administered to 975 students of schools in Taipei, Taiwan, Republic of China.

C. For each age group, the reliability, validity, and intercorrelations of the test items were obtained. The correlation between junior high school boys and elementary school boys are shown in Tables 2-1 and Table 2-2 (29:30-35).

D. The items selected to be included in the Chinese

Fitness Test were selected in accordance with the following three criteria: (the outcomes are shown in Table 2-3).

1. Among the items under the same factor, the one with higher reliability was selected.
2. Among the items under the same factor, the one which correlated highly with its composite scores was selected.
3. Among the items under the same factor, the one which correlated low with other factors was selected.

The factors and test items selected have been presented in Table 2-3.

Comments of the Investigation on the Present Study

As mentioned above, this physical fitness test was constructed in the Republic of China, and its procedure was objective. The test would probably be more suitable for Chinese school children than previous tests. However, an analysis of the data on each item revealed inadequacies as follows:

1. The reliability scores were too low. Table 2-1 and Table 2-2 show the 48 items and none of the reliability scores were above .90 while only one correlation was in the .80 -.89 range and all others were below .80. The reliability scores did not

reach the acceptable level for a good test.

2. Speed and agility were not independent factors. A review of the higher correlations revealed that the five speed items correlated with three items of agility. These items probably share some common factor indicating that speed and agility would not be independent.
3. The backward trunk extension and the forward trunk extension under the factor flexibility correlated very low (.12 - .49). These two items are not of the same function (29:31-33). Therefore both of these items cannot represent flexibility so they are the test items of agility and muscular strength of upper extremity.
4. The correlation of any two test items in each age group varies widely and cannot be considered the basis of choosing test items.

As indicated in the foregoing discussion, it is desirable to recast the nine factors of physical fitness assumed by the tryout test and the test items covered by them.

Summary

The review of the literature cited in this chapter, observed the structure of physical fitness and included such factors as speed, flexibility, endurance, agility, equilibrium, and coordination. Since the scope and method of the various

Table 2-1

Reliability and Validity of Test Items and Correlations among Various Items, Junior High School Boys from Chinese Ministry of Education, 1976 p. 26-28

Item	Rel	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	Val.
1	.46	6.13	084	083	018	072	030	024	022	034	047	019	032	054	027	036	043	044	057	058	056	015	015	002	012	.78
2	.68		6.73	092	092	080	034	029	030	041	050	026	023	065	027	025	040	044	065	069	066	020	019	007	015	.85
3	.56			6.75	091	079	033	026	032	043	050	029	024	062	029	028	040	047	065	067	062	022	016	006	015	.85
4	.76				6.82	084	033	027	037	044	053	031	019	068	031	025	037	044	064	068	063	022	016	005	018	.86
5	.65					6.17	032	026	030	038	050	027	022	056	023	022	035	043	058	068	059	019	013	009	013	.78
6	.65						4.59	034	006	019	028	013	013	035	016	018	014	022	025	039	034	006	009	006	012	.45
7	.67							4.95	021	031	009	022	015	033	029	013	015	030	041	034	033	021	016	014	017	.47
8	.42								4.34	062	019	016	006	028	024	011	014	019	034	022	030	020	013	004	007	.44
9	.56									6.37	025	021	007	033	033	027	033	032	037	030	036	024	019	012	014	.58
10	.50										6.40	031	036	042	006	027	032	032	043	051	045	014	017	008	016	.62
11	.49											4.01	009	025	015	018	016	022	031	032	025	012	001	019	005	.42
12	.51												2.94	010	007	034	029	006	006	019	015	003	004	005	000	.26
13	.74													7.81	024	012	021	040	061	066	054	025	030	003	016	.72
14	.56														4.55	023	022	041	029	024	024	009	016	003	015	.43
15	.59															4.15	080	031	020	020	017	007	001	005	004	.45
16	.66																5.27	038	031	035	023	008	001	006	007	.54
17	.67																	6.10	043	046	032	020	006	008	009	.60
18	.62																		7.56	067	068	024	022	002	020	.76
19	.51																			7.85	065	027	015	005	021	.78
20	.58																				7.08	021	013	007	020	.72
21	.11																					3.39	006	004	002	.33
22	.28																						2.68	005	013	.28
23	.01																								002	.17
24	.23																									.28

Table 2-2

Reliability and Validity of Test Items and Correlations among Various Items, Elementary School Boys

Item	Rel	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	Val.
1	.69	6.89	089	088	086	086	025	017	000	006	041	048	046	053	016	024	019	009	052	067	063	054	060	025	029	.77
2	.70	5.47	093	091	092	027	018	001	009	039	050	049	052	019	029	025	010	052	067	067	046	060	028	029		.81
3	.73	7.17	091	088	032	018	004	007	035	047	048	053	022	026	020	011	051	069	065	061	062	033	032			.81
4	.80	7.81	093	032	019	003	011	038	047	047	050	019	026	022	007	056	067	066	060	062	029	031				.81
5	.71	7.30	034	019	003	010	034	049	048	053	022	027	022	009	055	072	066	059	062	028	031					.82
6	.53	4.93	021	023	013	002	027	017	041	002	003	006	004	035	049	038	044	039	023	018						.40
7	.83	3.41	010	003	004	015	014	023	025	013	011	012	016	029	034	026	025	023	012							.33
8	.27	1.68	059	042	000	012	002	006	016	022	004	000	014	000	003	003	004	014								.16
9	.26	1.94	038	001	007	006	008	013	024	009	005	002	009	006	007	006	013									.24
10	.58	5.97	029	040	036	022	046	051	025	032	025	039	025	023	015	020										.57
11	.70	6.31	050	044	008	024	023	004	040	053	051	046	054	025	029											.61
12	.69	3.77	040	017	033	029	024	046	046	047	046	049	034	028												.65
13	.80	7.91	006	021	014	018	043	061	060	065	062	032	034													.69
14	.61	3.16	033	039	026	002	011	019	014	012	003	012														.33
15	.66	4.91	090	032	022	024	037	023	019	018	016															.51
16	.73	4.56	032	018	018	031	016	014	015	016																.48
17	.75	2.96	020	020	026	022	016	014	009																	.33
18	.67	6.77	064	070	060	061	042	026																		.69
19	.85	8.25	078	064	067	036	029																			.80
20	.83	8.58	070	070	048	035																				.84
21	.79	8.21	083	052	042																					.77
22	.52	8.27	047	040																						.77
23	.43			029																						.50
24	.42																									.48

Table 2-3

Chinese Education Ministry Physical Fitness Test

Number	Factor	The Selected Test Item	For Age Group
I	Speed	50m Sprint	Boys & girls of any age group
II	Flexibility	Trunk extension forward	Boys & girls of any age group
III	Endurance	600m run	Boys & girls of elementary school
		800m run	Girls of junior high school & above
		1000m run	Boys of junior high school & above
IV	Strength of upper extremity	Grip	Boys & girls of any age group
		Pull-ups	Boys of elementary school & above
		Flexed arm hang	Girls of elementary school & above
V	Strength of trunk	Sit-ups for 1 minute	Boys & girls of junior high school and above
		Sit-ups for 30 seconds	Boys & girls of elementary school

Table 2-3 (continued)

Chinese Education Ministry Physical Fitness Test

Number	Factor	The Selected Test Item	For Age Group
VI	Agility	Shuttle run, side-step	Boys & girls of any age group
VII	Power	Standing long jump	Boys & girls of any age group
VIII	Coordination	Softball throw for distance	Boys & girls of any age group

investigators differed and their outcomes varied, there was no real consensus.

CHAPTER III

METHODS

The study was an analysis of physical fitness components for the purpose of selecting items for a physical fitness test suitable for the Chinese people. The following describes the procedures used for the analysis.

Subjects

The subjects for this study were the seventh grade students from Jui-Fong Junior High School and Kuang-Hua Junior High School in Kaohsiung, Taiwan. One hundred students, 50 from each school, were originally selected for the study and 80 of the students completed all the test items.

Age

The subjects were between the ages of 12 and 13. This age group was selected because the reliability and validity scores on the Chinese Education Ministry tryout test was more favorable for this age and less favorable for older ages (see Table 3-1 and Table 3-2).

Sex

Male students were selected for the study because they

Table 3-1

Reliability score for Each Subtest for Each Group on the Chinese Education Ministry's Physical Fitness Test.

Factor Item	Group	Senior School Boys	Senior School Girls	Junior School Boys	Junior School Girls	Elementary School Boys	Elementary School Girls
1		012	033	046	043	069	054
2		021	041	068	036	070	067
3	I	029	043	056	037	073	073
4		009	041	076	054	080	077
5		034	048	065	034	071	086
6		075	058	065	081	053	078
7	II	098	064	067	070	083	082
8		017	052	042	044	027	074
9	III	015	043	056	044	026	061
10		035	048	050	070	058	034
11	IV	055	008	049	064	070	069
12		055	026	051	051	069	058
13		086	073	074	058	080	083
14	V	072	039	056	043	061	055
15		032	045	059	048	066	060
16	VI	027	057	066	068	073	068
17		082	058	067	050	075	077
18		060	051	062	053	067	074
19	VII	055	059	051	066	085	082
20		056	050	058	047	083	061
21	VIII	089	017	011	077	079	082
22		072	077	028	076	052	047
23	IX	049	029	-001	-006	043	036
24		019	030	023	017	042	036

Table 3-2

Validity of Each Subtest of Each Group on the Chinese Education Ministry's Physical Fitness Test.

Item Factor	Group	Senior School Boys	Senior School Girls	Junior School Boys	Junior School Girls	Elementary School Boys	Elementary School Girls
	1	.68	.77	.78	.64	.77	.81
	2	.52	.76	.85	.65	.81	.86
I	3	.64	.78	.85	.77	.81	.80
	4	.68	.69	.86	.74	.81	.88
	5	.78	.80	.78	.56	.82	.88
II	6	.17	.28	.45	.32	.40	.52
	7	.36	.30	.47	.41	.33	.40
III	8	.39	.35	.44	.57	.16	.51
	9	.27	.39	.58	.63	.24	.51
	10	.43	.61	.62	.48	.57	.36
IV	11	.36	.40	.42	.59	.61	.71
	12	.44	.43	.26	.16	.65	.57
	13	.42	.41	.72	.49	.69	.66
V	14	.21	.28	.43	.50	.33	.52
	15	.20	.32	.45	.48	.51	.40
VI	16	.38	.33	.54	.54	.48	.29
	17	.42	.52	.60	.53	.33	.44
	18	.47	.56	.76	.65	.69	.73
VII	19	.52	.54	.78	.62	.80	.75
	20	.67	.52	.72	.71	.84	.84
VIII	21	.67	.27	.33	.61	.77	.72
	22	.46	.62	.28	.67	.77	.34
IX	23	.18	.32	.17	.34	.50	.50
	24	.02	.24	.28	.28	.48	.50

had higher validity scores than the girls on the Chinese Education Ministry's tryout test. This test also shows the male students physical fitness level was higher than girls (see Table 3-1 and Table 3-2).

Instrument of the Study

The use of a test should fit the objectives of a study. The major objective of this study was to analyze the basic factors of the structure of physical fitness. Therefore, the test was constructed in a manner to allow for the synthesis of physical fitness. Consequently, this study summed up the test items of the Chinese Education Ministry's Tryout Test as shown. (See "Tryout Items" on p. 13 and 14 for titles of factors and items.)

After reviewing the Ministry's tryout test and the pertinent literature, a test of 29 items was selected for this study (see Table 3-3).

The items used were adapted from the available tests including the International Committee on the Standardization of Physical Fitness Test (ICSPFT) (37:186-196) and the Chinese Education Ministry's Physical Fitness Test. The test items included sprinting, running, throwing, climbing, and abilities such as flexibility, agility, coordination, and the size of body. Therefore, the outcome of the twenty-nine subtests encompassed physical fitness as a whole. In other words, the subtests have formal validity, but the experi-

Table 3-3

Reliability Scores for the Fitness Tests Used in This Study

	Test Item	Reliability
1.	40m	.90
2.	50m	.91
3.	60m	.90
4.	80m	.89
5.	100m	.92
6.	Trunk extension backward	.81
7.	Trunk extension forward	.82
8.	800m	.80
9.	1000m	.78
10.	1200m	.77
11.	Shuttle Run	.74
12.	Side-steps	.80
13.	Zig-zag run	.80
14.	Grip strength	.86
15.	Push-up	.72
16.	Pull-ups	.84
17.	Sit-ups for 30 seconds	.78
18.	Sit-ups for one minute	.80
19.	Vertical jump	.84
20.	Standing long jump	.84
21.	Triple jump	.87
22.	Softball throwing for distance	.89
23.	Handball throwing for distance	.82
24.	Shot-put	.85
25.	Baseball throwing for accuracy	.52
26.	Softball throwing for accuracy	.56
27.	Height	.98
28.	Weight	.94
29.	Chest girth	.94

Table 3-4

Reliability of the Japanese Athletic Ability Test

Test Item	Reliability
1. Endurance of Muscular Strength & Muscle	
*(1) Pull-ups	high
(2) Flex and stretch arms on parallel bar	high
*(3) Sit-ups	marked
(4) Lift legs	marked
(5) Push-ups	low
2. Endurance of Respiratory Function	
*(1) Run beyond 150 yards	high
(2) Standing run	low
(3) Squat jump	low
(4) Endurance index	high
3. Power	
*(1) Vertical jump	high
*(2) Standing long jump	high
(3) Long jump	high
*(4) Triple jump	high
*(5) Shuttle run	high
4. Flexibility	
*(1) Trunk extension forward	high
*(2) Trunk extension backward	high
(3) Straight-knee floor touches	high
5. Speed	
*(1) 50 yd. run	high
*(2) 60 yd. run	high
*(3) 75 yd. run	high
*(4) 100 yd. run	high
6. Agility	
(1) Brupee test	
(2) Agility run	
7. Coordination	
*(1) Zig-zag run	high
(2) Shift direction test	high
(3) Bar snap	marked

Table 3-4 (continued)

Test Items	Reliability
8. Equilibrium	
(1) Walk on the balance platform	low
(2) Test of balance in motion	low
(3) Standing with eyes open and closed (various postures)	low
9. Accuracy	
*(1) Baseball throwing for accuracy	low
(2) Football throwing for accuracy	low
(3) Basketball throwing for accuracy	low

mental validity will be left for further study because of no adequate norm to serve as a validation criteria.

The reliability scores of the 29 test items were obtained by means of the test-retest method as shown in Table 3-3. These test items were higher than those of the Education Ministry's test (see Table 3-1). Among the twenty-nine subtest items, only the reliability scores of baseball throwing for accuracy and softball throwing for accuracy were considered too low. For the purpose of making comparison, the investigator of the present study summed up the reliability scores of the Japanese Body Strength Test as shown in Table 3-4. In the table, items symbolized by "*" indicated those items most related to the test items used in this study.

As compared with Table 3-1 and Table 3-3, the reliability of the Japanese Body Strength Test was higher (37:196-197). Additional research on behalf of the Chinese research worker was considered warranted so as to investigate why the reliability of their test items was not high enough.

Testing Procedure

Collection of Data

The tests for this study were administered to the seventh grade male students of Jui-Fong and Kuang-Hua Junior High Schools in Kaohsiung City, Taiwan. In order to ensure reliable test results, a test manual was prepared. Prior to conducting the test, a workshop was conducted for

those high school teachers who administered the testing program. The particular site for testing, each item, the instruments to be used, and the methods of testing, were specified in the manual, explained and discussed in detail to assure that standard procedures were followed. The testing program was supervised by the investigator of this study.

Processing of data

Since there were 29 variables in this study and the factor analysis was employed, the data was processed and analyzed by IBM computer at the Computer Center of Tamkang University, Taipei, Taiwan. The process was completed as follows:

(1) A correlation matrix was formed showing the relationship of the 29 sub-tests.

(2) The correlation matrix was used for principal component analysis, resulting in the factor variance of the 29 variables or eigenvalue, and the number of factors were decided with Bi-factor solution.

(3) After deciding the number of factors, the Minimum Residual Factor Analysis (14:563-571) was employed to get the factor matrix.

(4) From the rotated factor matrix, the common factors were obtained and designated and interpreted adequately.

CHAPTER IV

ANALYSIS AND DISCUSSION OF DATA

The purpose of this study was to investigate the factors of physical fitness of Chinese junior high school boys in The Republic of China. Twenty-nine subtests were administered to 80 students. Intercorrelations were computed and a factor analysis was applied to identify the major factors.

Statistical Treatment

The first step of the factor analysis was to obtain the correlation coefficient symmetrical matrix, as shown in Table 4-1. The values in the matrix were the product-moment correlation coefficient of two related subtests.

The data in Table 4-1 indicated that some variables had quite high coefficients; for example, $r_{1.2} = 0.7696$, $r_{3.4} = 0.814$, $r_{3.5} = 0.921$, $r_{9.10} = 0.9366$. These highly correlated variables may be determined by a few common factors, and therefore, common factors can be extracted from the twenty-nine subtests.

The second step of the factor analysis was to determine the adequate number of common factors from the coefficient matrix. Table 4-1 was used for the principal component analysis and for the factor variance of the twenty-nine

subtests or "eigenvalues" and the percentage of the total variance as shown in Table 4-2.

The principal concern was to group the closely related variables in a large set variables into a small number of factors, which described the variance of the original set of variables. This was to attain economy of description. Thus, the basic principle in factor analysis is the less factors extracted the better; and the larger the variance of the variables conveyed by the extracted factor, the better (40:847-849).

Using this principle, the study employed the method of determining the number of factors developed by H. F. Kaiser (17:187-200). Kaiser's theory employed the following rationale: since the scores of each variable are standardized, its variance is 1.0; and after the principal factor analysis is employed, the variance of the variables which the extracted factors account for should not be less than 1.0; otherwise, the extracted factors are not so effective as a single variable in accounting for the variance. Considering this principle, P_9 -P_{29} in Table 4-2 can be taken as error, and so they should be discarded. The remaining eight factors still accounted for the large part of variances of the variables in the original correlation matrix (about 75%).

Among the foregoing eight extracted factors, the last one (P_8), whose variance was close to 1 and whose effect of

accounting for the variance of variables was similar to a single variable, and did not contribute much. Moreover, when R. B. Cattell's "scree' test" was employed to determine the number of factors (as shown in Figure 4-1), it was observed that the curve between P_7 and P_8 was declining greatly. Therefore, it seemed proper to discard all factors after P_8.

In order to get a more satisfactory outcome, the eight factors were compared with the seven factors and found that, after rotation, the loadings of all the subtests on P_8 were either negative or near zero (See Table 4-5). These scores did not meet the requirement of rotation and created considerable difficulty in interpretation. Thus, the investigation determined that seven factors should be excluded. In this manner, they still accounted for 71.3% of the total variance and attain the economy of description, which the factor analysis was aimed at.

After determining the number of factors, Harman's Minres (Minimum Residual Factor Analysis) was employed to extract the common factors. The advantage of this method was that through the process of iteration a set of communality was found and placed in the principal diagonal of the original correlation matrix (See Table 4-1) as the outcome of factor analysis. Not only were the number of factors less than that of variables, but also the estimated correlations were close to the original ones.

Figure 4-1

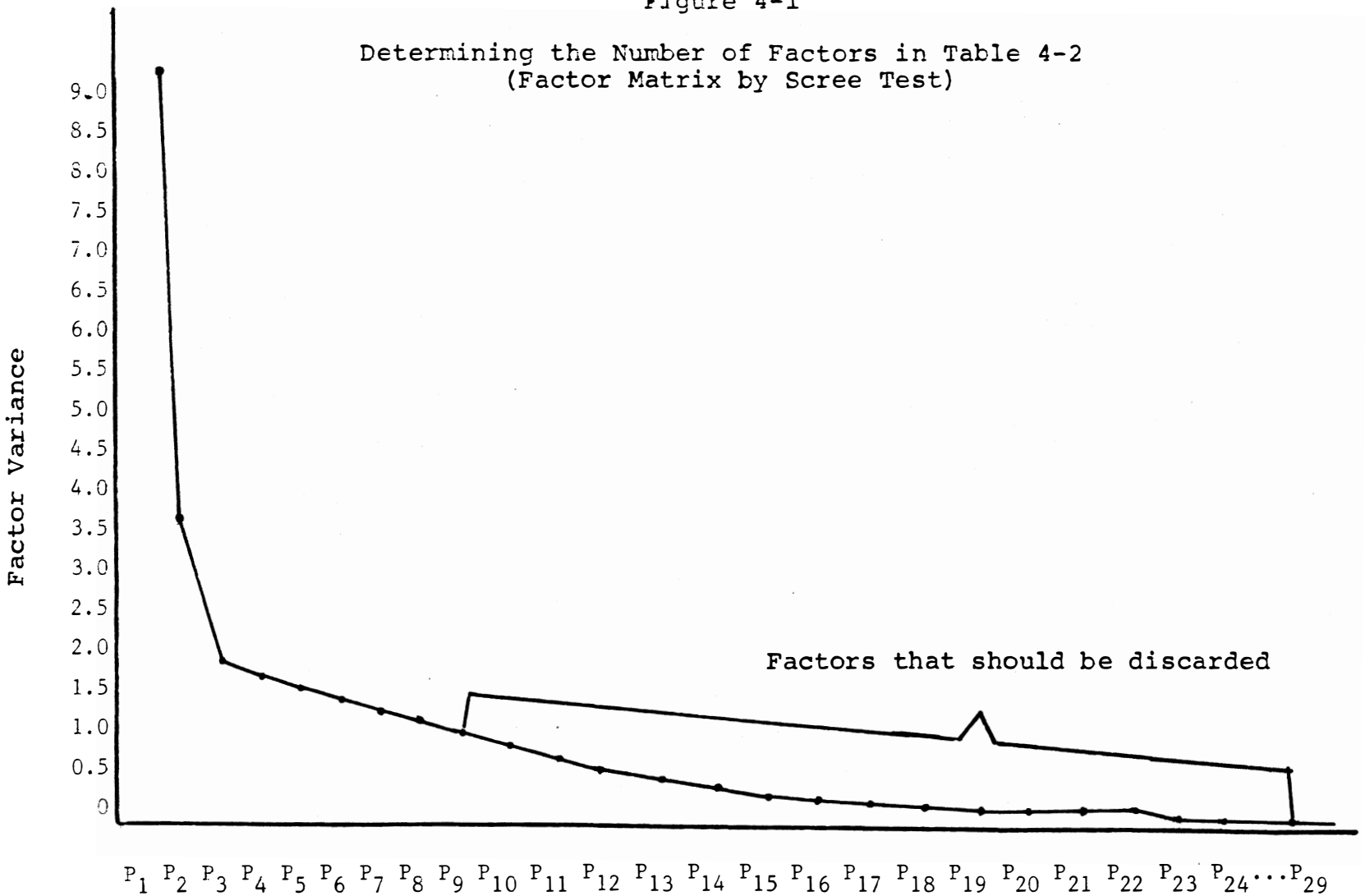
Determining the Number of Factors in Table 4-2
(Factor Matrix by Scree Test)
Factor Variance
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0
Factors that should be discarded
P1 P2 P3 P4 P5 P6 P7 P8 P9 P10 P11 P12 P13 P14 P15 P16 P17 P18 P19 P20 P21 P22 P23 P24...P29

Table 4-3 illustrates the extracted common factor matrix, obtained through the foregoing method. In the matrix, the columns designated with P_1, P_2, . . . P_7, represent seven dimensions. The values in the matrix were factor-loadings, which represent the relationship between the variable and one factor dimension. For example, variable 3 had a loading of .846 in Factor P_1, which meant that the variance of variable 3 has contributed to the large part of the variance of P_1. In the same manner all values in the matrix were interpreted.

At the bottom of the matrix, in the first row the values were factor variances or eigenvalues, which were the sum of the sequence of factor loadings in each column. These values represented the variance of the variables in the original correlation matrix accounted by the factor. In the Table 4-2 the total variance was comprised of 29 units, while Factor P_1 accounted for 9.28 units of them, and P_2 accounted for 3.53 units. The remaining units may be inferred in the same manner.

In the last row of the matrix, the values were the percentage of the variance accounted for by the factor and the total variance, and each of them were obtained when the factor variance was divided by the total variance.

At the right-hand side of the matrix, the last column is entitled "variable variance" or "communality" designated as "h^2" representing the portion of the variance

Table 4-1

The Intercorrelation of Coefficients of the 29 Subtests

	1	2	3	4	5	6	7	8	9	10
1	1.0000	0.7696	0.7011	0.7092	0.7480	-0.1972	-0.0536	0.04009	0.3730	0.3877
2	0.7696	1.0000	0.7817	0.6944	0.7435	-0.0692	-0.0513	0.4635	0.4533	0.4869
3	0.7011	0.7817	1.0000	0.8184	0.9021	-0.0806	-0.0293	0.4792	0.4383	0.4463
4	0.7092	0.6944	0.8184	1.0000	0.7806	-0.2054	-0.0499	0.4968	0.4556	0.4462
5	0.7480	0.7435	0.9021	0.7806	1.0000	-0.0916	-0.0208	0.3984	0.3908	0.4054
6	-0.1972	-0.0692	-0.0806	-0.2054	-0.0916	1.0000	-0.0266	0.0321	-0.0049	-0.0803
7	-0.0536	-0.0513	-0.0293	-0.0499	-0.0208	-0.0266	1.0000	-0.0021	0.0050	0.0209
8	0.4009	0.4635	0.4792	0.4968	0.3984	0.0321	-0.0021	1.0000	0.7978	0.7358
9	0.3730	0.4533	0.4383	0.4556	0.3908	-0.0049	0.0050	0.7978	1.0000	0.9366
10	0.3877	0.4869	0.4463	0.4462	0.4054	-0.0803	0.0209	0.7358	0.9366	1.0000
11	0.5792	0.5416	0.5606	0.5092	0.5922	-0.1255	0.0569	0.2450	0.3267	0.3238
12	-0.0463	0.0771	0.0363	0.0648	0.0756	0.2188	0.0424	-0.0045	-0.0483	0.0196
13	0.1274	0.2970	0.3308	0.1820	0.3323	0.0957	0.1570	0.2275	0.2968	0.2822
14	0.3428	0.4094	0.3856	0.3966	0.4295	0.0405	0.2025	0.1863	0.1229	0.1265
15	0.3835	0.3137	0.3539	0.3509	0.3294	-0.2343	0.1725	0.2940	0.3775	0.4535

Table 4-1 (cont.)

The Intercorrelation of Coefficients of the 29 Subtests

	11	12	13	14	15	16	17	18	19	20
1	0.5792	-0.0463	0.1274	0.3428	0.3835	0.4534	0.3447	0.2931	0.4133	0.4855
2	0.5416	0.0771	0.2970	0.4094	0.3137	0.3576	0.3456	0.2965	0.5260	0.4987
3	0.5606	0.0363	0.3308	0.3856	0.3539	0.4823	0.4856	0.5275	0.5467	0.4738
4	0.5092	0.0648	0.1820	0.3966	0.3509	0.5229	0.3587	0.3510	0.5264	0.4791
5	0.5922	0.0756	0.3323	0.4295	0.3294	0.4652	0.4073	0.4564	0.5653	0.5389
6	-0.1255	0.2188	0.0957	0.0405	-0.2343	-0.1715	-0.0574	-0.0479	0.0758	-0.0222
7	0.0569	0.0424	0.1570	0.2025	0.1725	0.1519	-0.0639	0.0478	0.1417	0.1648
8	0.2450	-0.0045	0.2275	0.1863	0.2940	0.3081	0.2935	0.2317	0.1655	0.1720
9	0.3267	-0.0483	-0.2968	0.1229	0.3775	0.3041	0.2678	0.2124	0.2063	0.1929
10	0.3638	0.0196	0.2822	0.1265	0.4535	0.3220	0.1977	0.1900	0.2439	0.2113
11	1.0000	0.0201	0.3462	0.2591	0.4361	0.4386	0.2578	0.2080	0.3870	0.4803
12	0.0201	1.0000	0.1769	0.1924	0.0815	0.1214	-0.0555	0.0299	0.2380	0.2133
13	0.3462	0.1769	1.0000	0.2573	0.1423	0.0668	0.1792	0.2183	0.2758	0.1688
14	0.2591	0.1924	0.2573	1.0000	0.2293	0.2603	0.1763	0.1651	0.4341	0.3947
15	0.4361	0.0815	0.1423	0.2293	1.0000	0.5381	0.3613	0.3277	0.2508	0.2930

Table 4-1 (cont.)

The Intercorrelation of Coefficients of the 29 Subtests

	21	22	23	24	25	26	27	28	29
1	0.1588	0.1993	0.4416	0.1348	0.0850	0.4255	0.2850	0.1576	0.1723
2	0.2997	0.3158	0.4846	0.2380	0.1603	0.4611	0.3997	0.1797	0.2436
3	0.1071	0.1948	0.5165	0.2283	0.1334	0.5296	0.3147	0.1737	0.2140
4	0.1186	0.1284	0.4517	0.1548	0.0833	0.4550	0.3423	0.1492	0.1952
5	0.0992	0.1512	0.4791	0.2025	0.1437	0.5208	0.2993	0.1702	o.1723
6	0.1955	0.1135	0.0116	-0.0082	-0.0560	0.0381	0.0268	0.0223	0.0635
7	0.0468	0.2285	-0.0454	0.1544	0.0236	0.2369	0.0173	0.1127	0.3025
8	0.2009	0.0808	0.2911	0.1753	0.0234	0.2316	0.1008	-0.0252	0.0405
9	0.1618	0.1509	0.2705	0.1906	0.0443	0.1964	0.0637	-0.0548	0.0038
10	0.1735	0.2018	0.3068	0.1913	0.0521	0.1958	0.0642	-0.0577	0.0107
11	0.1691	0.2999	0.3989	0.1816	0.1245	0.3422	0.1884	0.1602	0.2180
12	0.1062	-0.0800	0.0946	-0.0719	0.0034	0.1456	0.1489	0.0295	0.0957
13	0.1695	0.2999	0.3028	0.2531	0.1355	0.3090	0.2198	0.1494	0.1384
14	-0.0549	0.2245	0.5492	0.2774	0.2414	0.8250	0.8043	0.7403	0.7292
15	.0944	0.2010	0.3207	0.1214	0.2268	0.3140	0.1551	0.0984	0.1840

Table 4-1 (cont.)

The Intercorrelation of Coefficients of the 29 Subtests

	1	2	3	4	5	6	7	8	9	10
16	0.4534	0.3576	0.4823	0.5229	0.4652	-0.1715	0.1519	0.3081	0.3041	0.3220
17	0.3547	0.3456	0.4856	0.3587	0.4073	-0.0574	-0.0639	0.2935	0.2678	0.1977
18	0.2931	0.2965	0.5275	0.3510	0.4564	-0.0479	0.0478	0.2317	0.2124	0.1900
19	0.4133	0.5260	0.5467	0.5264	0.5653	0.0758	0.1417	0.I655	0.2063	0.2439
20	0.4855	0.4987	0.4738	0.4791	0.5389	-0.0222	0.1648	0.1720	0.1929	0.2113
21	0.1588	0.2997	0.1071	0.1186	0.0992	0.1955	0.0468	0.2009	0.1618	0.1735
22	0.1993	0.3158	0.1948	0.1284	0.1512	0.1135	0.2285	0.0808	0.1509	0.2018
23	0.4416	0.4846	0.5165	0.4517	0.4791	0.0116	-0.0454	0.2911	0.2705	0.3068
24	0.1348	0.2480	0.2283	0.1548	0.2025	-0.0082	0.1544	0.1753	0.1906	0.1913
25	0.0850	0.1603	0.1334	0.0833	0.1437	-0.0560	0.0236	0.0234	0.0443	0.0521
26	0.4255	0.4611	0.5296	0.4550	0.5208	0.0381	0.2369	0.2316	0.1964	0.1958
27	0.2850	0.3997	0.3147	0.3423	o.2993	0.0268	0.0173	0.1008	0.0637	0.0642
28	0.1576	0.1979	0.1737	0.1492	0.1702	0.0223	0.1127	-0.0252	0.0548	0.0642
29	0.1723	0.2436	0.2140	0.1952	0.1723	0.0635	0.3025	0.0405	0.0038	0.0107

Table 4-1 (cont.)

The Intercorrelation of Coefficients of the 29 Subtests

	11	12	13	14	15	16	17	18	19	20
16	0.4386	0.1214	0.0668	0.2603	0.5381	1.0000	0.3942	0.4036	0.3445	0.4595
17	0.2578	-0.0555	0.1792	0.1763	0.3613	0.3942	1.0000	0.8591	0.3284	0.2178
18	0.2080	0.0299	0.2183	0.1651	0.3277	0.4036	0.8591	1.0000	0.3469	0.2437
19	0.3870	o.2380	0.2758	0.4341	0.2508	0.3445	0.3284	0.3459	1.0000	0.6067
20	0.4803	0.2133	0.1688	0.3947	0.2930	0.4595	0.2178	0.2437	0.6067	1.0000
21	0.1691	-0.1062	0.1695	-0.0549	0.0944	0.1434	0.1800	0.0213	0.1236	0.1880
22	0.2999	-0.0800	0.2949	0.2245	0.2010	0.2617	0.0803	-0.0029	0.1717	0.1631
23	0.3989	0.0946	0.3028	0.5492	0.3207	0.2869	0.3085	0.2276	0.4278	0.4164
24	0.1816	-0.0719	0.2531	0.2774	0.1214	0.1434	0.1786	0.1705	0.2172	0.1937
25	0.1245	0.0034	0.1355	0.2414	0.2268	0.1025	0.0617	0.0620	0.1464	0.2276
26	0.3422	0.1456	0.3090	0.8250	0.3140	0.4015	0.3033	0.2994	0.4703	0.4791
27	0.1884	0.1489	0.2198	0.8043	0.1551	0.0471	0.1757	0.0487	0.3513	0.2445
28	0.1602	0.0295	0.1494	0.7493	0.0984	-0.0012	0.0131	-0.0233	0.2963	0.2576
29	0.2180	0.0957	0.1384	0.7292	0.1840	0.2350	0.0987	0.1234	0.2963	0.2756

Table 4-1 (cont.)

The Intercorrelation of Coefficients of the 29 Subtests

	21	22	23	24	25	26	27	28	29
16	0.1434	0.2617	0.2869	0.1434	0.1025	0.4015	0.0471	-0.0012	0.2350
17	0.1800	0.0803	0.3085	0.1786	0.0617	0.3033	0.1757	0.0131	0.0987
18	0.0213	-0.0029	0.2276	0.1705	0.0620	0.2294	0.0487	-0.0233	0.1234
19	0.1236	0.1717	0.4278	0.2172	0.1464	0.4703	0.3513	0.2328	0.2963
20	0.1800	0.1631	0.4164	0.1937	0.2276	0.4791	0.2335	0.1156	0.2756
21	1.0000	0.5976	0.0035	0.0392	-0.0574	-0.0018	0.0572	-0.0922	-0.0041
22	0.5976	1.0000	0.4075	0.2936	0.0879	0.2813	0.3189	0.2418	0.3017
23	0.0035	0.4075	1.0000	0.3670	0.2445	0.5898	0.5991	0.3810	0.4328
24	0.0392	0.2936	0.3670	1.0000	0.2312	0.3012	0.1037	0.1120	0.1900
25	-0.0574	0.0879	0.2445	0.2312	1.0000	0.2873	0.2934	0.2355	0.2051
26	-0.0018	0.2813	0.5898	0.3012	0.2873	1.0000	0.6962	0.6323	0.6911
27	0.0572	0.3189	0.5991	0.1037	0.2934	0.6962	1.0000	0.7857	0.6467
28	-0.0922	0.2418	0.3810	0.1120	0.2355	0.6323	0.7857	1.0000	0.7400
29	-0.0041	0.3017	0.4328	0.1900	0.2051	0.6911	0.6467	0.7400	1.0000

Table 4-2

The Obtained Factor Matrix Based on Table 4-1
After Principal Component Analysis

	P_1	P_2	P_3	P_4	P_5	P_6	P_7	P_8
1	0.745124	-0.226432	-0.181055	-0.122116	-0.215919	-0.290415	-0.0348616	-0.0534836
2	0.806916	-0.165817	-0.0221659	-0.0921747	-0.310467	-0.0972006	-0.0727324	-0.0447802
3	0.846160	-0.226647	-0.198886	-0.0512537	-0.155425	0.0325813	-0.106412	-0.142181
4	0.787923	-0.233763	-0.260976	-0.172659	-0.166818	-0.102791	0.0346340	0.0720388
5	0.825186	-0.197307	-0.240765	-0.0463940	-0.-28552	-0.00717163	-0.00812258	-0.0934386
6	-0.0746409	0.167472	0.339084	0.160986	-0.378137	0.584213	-0.0516934	0.0909819
7	0.116687	0.226332	0.223771	0.401282	0.364816	-0.0628984	0.423458	0.110051
8	0.533308	-0.433804	0.340123	-0.354847	0.150352	0.208528	-0.0113152	0.153723
9	0.538500	-0.498161	0.426526	-0.348961	0.218175	0.162464	0.039018	0.0649705
10	0.554218	-0.485638	0.424336	-0.325726	0.205669	0.0912801	0.150597	0.0436426
11	0.654133	-0.149650	0.000177868	0.108995	-0.124720	-0.272714	0.153572	-0.124682
12	0.119359	0.164781	-0.102331	0.0597984	-0.203813	0.526571	0.560622	-0.0520823
13	0.418435	0.0333944	0.331033	0.136161	-0.0272810	0.321312	0.00886613	-0.338560
14	0.65778	0.619221	-0.0196806	-0.157077	0.0697341	0.0814539	0.0232885	0.105905
15	0.534930	-0.176914	-0.00192465	0.123638	0.444422	-0.174303	0.219640	0.120001

Table 4-2 (cont.)

The Obtained Factor Matrix Based on Table 4-1
After Principal Component Analysis

	P_9	P_{10}	P_{11}	P_{12}	P_{13}	P_{14}	P_{15}
1	-0.0493849	0.0226784	-0.00156210	-0.0582160	-0.0672038	-0.142874	-0.0138521
2	-0.0264715	0.0145361	-0.0785065	-0.120431	-0.0752599	-0.137800	-0.172550
3	-0.142181	-0.0355909	-0.0420156	0.0576407	-0.156875	-0.0105453	-0.0975258
4	-0.0942384	0.0525701	0.00552833	-0.108120	-0.130980	-0.0177245	0.0990451
5	-0.151161	-0.0517332	-0729841	0.0790919	0.132153	-0.0700306	-0.0519329
6	0.100582	0.266574	-0.0399558	0.458648	-0.0451690	-0.162324	-0.00471612
7	-0.468041	0.0236818	-0.240549	-0.0481880	-0.0451673	-0.251777	0.0732054
8	-0.0380875	0.162507	-0.0626130	-0.0299991	-0.105780	0.0884463	-0.00260233
9	-0.00390069	0.0545122	-0.0594658	0.0236660	0.116497	0.0605402	0.0175056
10	0.0427970	0.00215249	0.000519856	-0.0389914	0.140472	-0.0166726	0.00208729
11	0.00588974	-0.295463	0.636422	0.398346	0.142070	0.105048	-0.181929
12	0.273107	-0.166366	0.222701	-0.236241	-0.199507	-0.0518984	-0.15989
13	-0.160883	-0.582584	-0.110888	-0.00595864	-0.0535528	0.187786	0.0895947
14	-0.0782520	0.0519885	0.0113967	-0.437309	-0.0398106	0.0808076	-0.0753353
15	0.367703	-0.170421	0.0577952	0.0687157	0.105370	-0.251263	-0.141815
16	0.153769	0.132422	0.198680	0.194815	-0.248106	0.226947	0.164625

Table 4-2 (cont.)

The Obtained Factor Matrix Based on Table 4-1
After Principal Component Analysis

	P_{16}	P_{17}	P_{18}	P_{19}	P_{20}	P_{21}	P_{22}
1							
2							
3							
4							
5							
6				omitted			
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							

Table 4-2 (cont.)

The Obtained Factor Matrix Based on Table 4-1
After Principal Component Analysis

	P_{23}	P_{24}	P_{25}	P_{26}	P_{27}	P_{28}	P_{29}	Communality $(h)^2$
1								1
2								1
3								1
4								1
5					omitted			1
6								1
7								1
8								1
9								1
10								1
11								1
12								1
13								1
14								1
15								1
16								1

Table 4-2 (cont.)

The Obtained Factor Matrix Based on Table 4-1
After Principal Component Analysis

	P_1	P_2	P_3	P_4	P_5	P_6	P_7	P_8
16	0.594303	-0.214547	-0.151956	0.298928	0.219170	-0.155820	0.243073	0.223177
17	0.516044	-0.247483	-0.277554	0.326547	0.263175	0.270111	-0.487537	0.136260
18	0.486767	-0.244270	-0.377545	0.363691	0.311498	0.369148	-0.333670	0.0812968
19	0.658507	0.0830629	-0.160239	0.205062	-0.227852	0.186974	0.179902	-0.0833863
20	0.633357	0.0310148	-0.159167	0.249058	0.209843	-0.0579961	0.356426	-0.112794
21	0.205699	-0.183498	0.532439	0.454905	-0.345621	-0.173604	-0.215822	0.242725
22	0.385041	0.171287	0.602014	0.398000	-0.118475	-0.297129	-0.165308	0.0356539
23	0.697553	0.243095	0.0683196	-0.095300	-0.0145394	0.02129041	0.139533	-0.188800
24	0.355235	0.0861743	0.233729	0.155415	0.248439	0.0289933	-0.0137098	-0.573399
25	0.264257	0.250769	-0.0140624	-0.0333194	0.235709	-0.0915034	0.0181849	-0.535510
26	0.748004	0.484129	-0.0424388	-0.0223961	0.188329	0.0748515	0.00974336	0.0705090
27	0.558068	0.655775	0.0524795	-0.239762	-0.0762781	0.00599071	-0.187357	0.121896
28	0.391809	0.761369	0.0363349	-0.235620	0.0675957	-0.0760327	-0.137945	0.150770
29	0.480551	0.684782	0.0647246	0.00684248	0.175064	-0.0358793	0.0109337	0.236187
tor Var. gen- values)	9.28066	3.52518	1.04055	1.61674	1.50412	1.43341	1.35107	1.12949
of Total riance	32.00	12.16	6.71	5.57	5.19	4.94	4.66	3.89

Table 4-2 (cont.)

The Obtained Factor Matrix Based on Table 4-1
After Principal Component Analysis

	P_9	P_{10}	P_{11}	P_{12}	P_{13}	P_{14}	P_{15}
17	0.106099	-0.0378730	-0.0178374	-0.0593913	0.0958122	0.224055	-0.0768013
18	-0.0331210	-0.0522054	-0.0605889	-0.00856291	0.00375570	-0.0163963	-0.00652008
19	-0.0734271	0.128566	-0.0979837	-0.154892	0.383008	-0.0808204	0.0607140
20	0.570543	0.263005	-0.0941850	-0.0234876	0.246289	0.250943	0.0248632
21	0.162837	0.0523474	-0.180832	-0.195979	-0.0295572	0.125304	-0.128268
22.	0.0381964	-0.0719936	0.183390	-0.0618833	-0.0830429	-0.108368	0.166283
23	0.152509	0.0151218	0.370434	0.00458583	0.166570	-0.124236	0.310437
24	-0.240418	0.309566	0.340844	-0.0802182	-0.0760253	0.182345	-0.281339
25	0.484173	0.146124	-0.453425	0.0249460	-0.176325	-0.0311883	0.0607801
26	-0.067791	0.0707852	-0.01738880	0.0550824	-0.0935053	0.0883004	0.0504680
27	0.149845	-0.0925004	-0.0415250	-0.180973	0.0542721	-0.0429019	0.0159753
28	-0.0253906	-0.109550	-0.0723133	0.0707923	0.0466326	0.0234663	-0.114928
29	-0.0691641	0.0635303	0.00460327	0.116756	0.00305445	0.106695	-0.0744826
tor Var.	0.95623	0.85682	0.74441	0.61885	0.55789	0.46326	0.45123
qen lues)							
of Total riance	3.30	2.95	2.57	2.13	1.92	1.60	1.56

Table 4-2 (cont.)

The Obtained Factor Matrix Based on Table 4-1
After Principal Component Analysis

	P_{16}	P_{17}	P_{18}	P_{19}	P_{20}	P_{21}	P_{22}
17							
18							
19							
20							
21							
22				omitted			
23							
24							
25							
26							
27							
28							
29							
ctor Var. igen- alues)	0.41459	0.24718	0.29935	0.25545	0.25128	0.19279	0.17742
of Total ariance	1.43	1.20	.03	0.88	0.87	0.66	0.61

Table 4-2 (cont.)

The Obtained Factor Matrix Based on Table 4-1
After Principal Component Analysis

	P_{23}	P_{24}	P_{25}	P_{26}	P_{27}	P_{28}	P_{29}	Commun-ality (h^2)
17								1
18								1
19								1
20				omitted				1
21								1
22								1
23								1
24								1
25								1
26								1
27								1
28								1
29								1
actor Var. Eigen-values)	0.15345	0.14183	0.11346	0.07995	0.06067	0.04766	0.02967	29
of Total ariance	0.53	0.49	0.39	0.28	0.21	0.16	0.10	100

Table 4-3

Factor Matrix Obtained from Table 4-1 by Iteration

Variable	P_1	P_2	P_3	P_4
1. 40m	0.745124	-0.226432	-0.181055	-0.112116
2. 50m	0.806916	-0.165817	-0.022166	-0.092175
3. 60m	0.846160	-0.226647	-0.198866	-0.015254
4. 80m	0.787923	-0.233763	-0.206976	-0.172659
5. 100m	0.825186	-0.197307	-0.240765	-0.046394
6. Trunk extension backward	-0.074641	0.167472	0.339084	0.160986
7. Trunk extension forward	0.116867	0.226332	0.223771	0.410282
8. 800m	0.533308	-0.433804	0.340128	-0.354847
9. 1000m	0.538500	-0.498161	0. 426526	-0.348961
10. 1200m	0.554218	0.485638	0.424336	-0.325726
11. Shuttle run	0.654133	-0.149650	0.000178	0.108995
12. Side steps	0.119359	0.164781	-0.102331	0.059798
13. Zig Zag run	0.418435	0.033394	0.331033	0.136161
14. Grip strength	0.657778	0.619211	-0.019681	-0.157077
15. Push-up	0.534930	-0.176914	-0.001925	0.123638
16. Pull-up	0.594303	-0.214547	-0.0151956	0.298928

Table 4-3 (cont.)

Factor Matrix Obtained from Table 4-1 by Iteration

Variable	P_5	P_6	P_7	Communality (h^2)
1. 40m	-0.215919	-0.290415	-0.034862	0.784009
2. 50m	-0.310467	-0.097201	-0.062632	0.797356
3. 60m	-0.155425	-0.032581	-0.106412	0.846080
4. 80m	-0.166818	-0.102791	-0.034634	0.787712
5. 100m	-0.223552	-0.007172	-0.008123	0.832335
6. Trunk extension backward	-0.367137	0.584213	-0.051693	0.653279
7. Trunk extension forward	0.364316	0.062898	0.423458	0.592348
8. 800m	0.150352	0.208528	-0.011315	0.784788
9. 1000m	0.218175	0.162464	0.063902	0.919923
10. 1200m	0.205669	0.091280	0.150597	0.902472
11. Shuttle run	-0.124720	-0.272714	0.153572	0.575678
12. Side steps	0.203313	0.526571	0.560622	0.688560
13. Zig Zag Run	0.027231	0.321312	0.008866	0.408390
14. Grip strength	0.069734	0.081454	0.023289	0.853195
15. Push-up	0.444422	-0.174030	0.219640	0.608779
16. Pull-up	0.219170	-0.155820	0.243070	0.643075

Table 4-3 (cont.)

Factor Matrix Obtained from Table 4-1 by Iteration

Variable	P_1	P_2	P_3	P_4
17. Sit-up for 30 sec.	0.516044	-0.247483	-0.277554	0.326547
18. Sit up for 1 min.	0.486767	-0.244270	-0.377545	0.363691
19. Vertical jump	0.658507	0.083063	-0.160239	0.205062
20. Standing long jump	0.633357	0.031015	-0.159167	0.249058
21. Triple jump	0.205699	-0.183498	0.532439	0.454905
22. Softball throwing for distance	0.335041	0.171287	0.602014	0.398000
23. Handball throwing for distance	0.697553	0.243095	0.068320	-0.099530
24. Shot put	0.355235	0.086174	0.233729	0.155415
25. Baseball throwing for accuracy	0.264257	0.250769	-0.014062	-0.033319
26. Softball throwing for accuracy	0.748004	0.434129	-0.042439	-0.022396
27. Height	0.558068	0.655775	0.052480	-0.239762
28. Weight	0.391809	0.761369	0.036336	-0.235620
29. Chest girth	0.480551	0.684782	0.064725	0.006842
Factor Variance (Eigenvalues)	9.280674	3.525176	1.945953	1.616752
Percentage of Total Variance	32.00	12.16	6.71	5.58

Table 4-3 (cont.)

Factor Matrix Obtained from Table 4-1 by Iteration

Variable	P5	P6	P7	Communality (h^2)
17. Sit-up for 30 sec.	0.263175	0.270111	-0.487537	0.891132
18. Sit-up for 1 min.	0.311498	0.369143	-0.338670	0.919421
19. Vertical jump	-0.227852	0.186974	0.179902	0.627498
20. Standing long jump	-0.209843	-0.057996	0.356426	0.663904
21. Triple jump	-0.345621	-0.173604	-0.215822	0.762584
22. Softball throwing for distance	-0.118475	-0.297129	-0.165308	0.828070
23. Handball throwing for distance	-0.014539	-0.021904	-0.139538	0.580411
24. Shot put	0.248439	0.028993	-0.137098	0.293759
25. Baseball throwing for accuracy	0.235709	-0.091503	0.018185	0.198287
26. Softball throwing for accuracy	0.118329	0.074852	0.009748	0.815893
27. Height	-0.076278	0.005991	-0.187357	0.842678
28. Weight	0.067596	-0.076033	-0.137945	0.819414
29. Chest girth	0.175064	-0.035879	0.010934	0.736147
Factor Variance (Eigenvalues)	1.504127	1.433408	1.351076	20.657166
Percentage of Total Variance	5.19	4.94	4.77	71.24

of each variable accounted for by the factor. The value was equal to the sum of the factor loading of each variable.

Rotation of Factor Axes

The result of the analysis of Table 4-3 was described as above. However, the factor matrix demonstrated that some of the variables have loadings on several factors (such as variables 26-29). Such a finding made the interpretation difficult. For this reason, the analysis must undergo the process of rotation in accordance with "Rules of Simple Structure" (32:65-70) to find out the pure variables; that is, after rotation the variable in the factor matrix should have loadings only on a few factors, and the more zero or near zero loadings the better. Thus, the complexity of factor analysis becomes simplified.

There are many methods of rotating the factor axes. The most commonly used methods are orthogonal rotation and oblique rotation. Because there are many criteria of "Simple Structure," it is a laborious and time-consuming work to rotate the factor axes adequately. At present, the process of rotation is primarily written into the computer program and computation is done by the computer. This method is called "Analytic Rotation Method." Two widely used methods are Varimax and Quartimax (30:81-91), but both of these methods permit only orthogonal rotation.

This study employed the Varimax method developed by

Kaiser. The rotation criterion of Varimax was that the sum of the squared loadings of the variable on each factor should be at maximum (30: 81-91), i.e., the values in each column of the factor matrix. By means of this method, the factor structure after rotation was simplified and easier to interpret. The factor matrix after rotation is shown as Table 4-4.

When comparing Table 4-4 with Table 4-3, after rotation, some of the negative factor loadings in the matrix had become larger; for example, Factor P_1:0.822329 and 0.83346, Factor P_2:0.859026 and 0.995124, with some values near zero (i.e., P_3:0.019572 and 0.023310, P_4:0.066894 and 0.071956). Moreover, in the matrix each variable has loadings only on a few factors (e.g., Variable 1 has loadings on P_1, Variable 8 has loadings on P_3).

It was evident that the rotated factor matrix of Table 4-4 has met the requirement of "pure" variable, and based upon it, the property of factor can thus be inferred.

Again, a comparison was made between the communality (h^2) of Table 4-3 and 4-4, and it was discovered that rotation of factor axes had little effect on communality, but great effect on the factor variance; for example, the value of P_1 changed from 9.280674 to 5.746120, and the value of Factor P_2 increased from, 3.525176 to 4.582070. Yet the variance these seven factors accounted for was not influenced by rotation.

Table 4-4

"The Rotated Factor Matrix" from Table 4-3 Through Varimax

Variable	P_1	P_2	P_3	P_4
1. 40m	o.822329*	0.150137	0.067922	0.074270
2. 50m	0.769331*	0.224772	0.217057	0.081707
3. 60m	0.782684*	0.204014	0.279040	0.022834
4. 80m	0.806702	0.175561	0.288181	-0.055189
5. 100m	0.833456*	0.185578	0.206829	0.001925
6. Trunk extension backward	-0.206257	0.026519	0.019572	0.290198
7. Trunk extension forward	-0.125131	0.158868	-0.023310	0.154579
8. 800m	0.256433	0.034104	0.835942*	0.037336
9. 1000m	o.239290	-0.006372	0.920903*	0.066894
10. 1200m	0.236157	-0.010056	0.891875*	0.071956
11. Shuttle run	0.661473*	0.116177	0.152458	0.202427
12. Side steps	0.132559	0.046392	-0.028064	-0.267060
13. Zig Zag run	0.112183	0.208870	0.308434	0.290018
14. Grip strength	0. 272720	0.859026*	0.059356	-0.036087
15. Push-up	0.316791	0.126820	0.314178	-0.015429
16. Pull-up	0.522940	0.027860	0.124335	0.032918

Table 4-4 (cont.)

"The Rotated Factor Matrix" from Table 4-3 Through Varimax

Variable	P_5	P_6	P_7	Communality (h^2)
1. 40m	0.074270	-0.193677	-0.030679	0.784010
2. 50m	0.081707	0.026505	-0.105742	0.797357
3. 60m	0.329422	0.245444	-0.061396	0.846081
4. 80m	0.129923	-0.051975	-0.021145	0.787712
5. 100m	0.235767	0.059619	-0.036398	0.832336
6. Trunk extension backward	0.037978	0.673197*	-0.266085	0.653280
7. Trunk extension forward	-0.043030	0.138955	0.711233*	0.592348
8. 800m	0.123548	0.033791	-0.035605	0.784788
9. 1000m	0.075804	0.004509	0.065727	0.919924
10. 1200m	0.005810	-0.004505	0.140756	0.902472
11. Shuttle run	0.004626	-0.064142	0.237232	0.575679
12. Side steps	-0.104999	0.745174*	0.174413	0.688562
13. Zig Zag run	0.173462	0.368953Δ	0.081798	0.408390
14. Grip strength	0.045292	0.161036	0.089914	0.853196
15. Push-up	0.203245	-0.183891	0.564151*	0.608779
16. Pull-up	0.257455	0.060937	0.431330*	0.643075

Table 4-4 (cont.)

"The Rotated Factor Matrix" from Table 4-3 Through Varimax

Variance	P_1	P_2	P_3	P_4
17. Sit-up for 30 sec.	0.271282	0.068859	0.110547	0.074088
18. Sit up for 1 min.	0.263306	0.027898	0.072864	-0.064769
19. Vertical jump	0.596694*	0.250474	-0.005928	0.058329
20. Standing long jump	0.674644*	0.162025	-0.055647	0.072435
21. Triple jump	0.174259	-0.153982	0.058289	0.837699*
22. Softball throwing for distance	0.125237	0.270290	0.067574	0.834514*
23. Handball throwing for distance	0.393353	0.574735*	0.215610	0.146773
24. Shot put	0.013152	0.282593Δ	0.210062	0.262021
25. Baseball throwing for accuracy	0.051643	0.375332Δ	0.039799	-0.035940
26. Softball throwing for accuracy	0.395854	0.769227*	0.087709	0.022303
27. Height	0.213752	0.861981*	0.013544	0.083421
28. Weight	0.035695	0.895184*	-0.077074	0.013018
29. Chest girth	0.079822	0.815518*	-0.065036	0.082219
Factor Variance (Eigenvalue)	5.746120	4.582070	3.043257	1897972
Percentage of Total Variance	19.81	15.80	10.51	6.54

Table 4-4 (cont.)

"The Rotated Factor Matrix" from Table 4-3 Through Varimax

Variance	P_5	P_6	P_7	Communality (h^2)
17. Sit up for 30 sec.	0.890007*	-0.053956	0.008040	0.891132
18. Sit-up for 1 min.	0.907409*	0.057910	0.114299	0.919421
19. Vertical Jump	0.191315	0.383732	0.146385	0.627499
20. Standing long jump	0.019842	0.253892	0.330620	0.663905
21. Triple jump	0.019636	0.052526	-0.015016	0.762585
22. Softball throwing for distance	-0.041818	-0.040127	0.186612	0.828070
23. Handball throwing for distance	0.157128	0.043857	-0.018136	0.580412
24. Shot put	0.246462	-0.024251	0.199036	0.293760
25. Baseball throwing for accuracy	0.052982	-0.101019	0.197127	0.198287
26. Softball throwing for accuracy	0.181338	0.140677	0.183868	0.815895
27. Height	-0.017099	0.064793	-0.158133	0.842679
28. Weight	-0.083024	-0.028350	-0.053915	0.819415
29. Chest girth	0.021402	0.068534	0.220366	0.736148
Factor Variance (Eigenvalue)	2.151710	1.542301	1.689771	20.657197
Percentage of Total Variance	7.42	5.32	5.83	71.23

Table 4-5

The Rotated Factor Matrix of the Eight Extracted Factors

Variable	P_1	P_2	P_3	P_4
1. 40m	0.812164*	0.159497	0.209139	0.076455
2. 50m	0.773737*	0.210848	0.295594	0.203320
3. 60m	0.785374*	0.181701	0.274927	0.016759
4. 80m	0.795167*	0.188286	0.306753	-0.044521
5. 100m	0.840706*	0.157964	0.198969	-0.017916
6. Trunk extension backward	-0.206741	0.073759	0.026165	0.308244
7. Trunk extension forward	-0.132082	0.141643	-0.023472	0.143013
8. 800m	0.238604	0.052267	0.851540*	0.050716
9. 1000m	0.230500	-0.017442	0.920940*	0.060948
10. 1200m	0.279447	-0.027431	0.889596*	0.062112
11. Shuttle run	0.672961*	0.068260	0.135471	0.169305
12. Side steps	0.131669	0.074932	-0.019949	-0.252170
13. Zig zag run	0.154756	0.104184	0.242773	0.206462
14. Grip strength	0.271634	0.854933*	0.064555	-0.052489
15. Push-up	0.301091	0.105235	0.322297	-0.021954
16. Pull-up	0.495116	0.047318	0.154403	0.055437

Table 4-5 (cont.)

The Rotated Factor Matrix of the Eight Extracted Factors

Variable	P_5	P_6	P_7	P_8	Communality (h^2)
1. 40m	0.093718	-0.203747	-0.006497	0.043476	0.7848705
2. 50m	0.079185	0.014108	-0.103082	-0.102108	0.7993617
3. 60m	0.325413	0.014014	-0.062702	-0.113095	0.8435051
4. 80m	0.131641	-0.061616	0.005786	0.047494	0.7929023
5. 100m	0.228183	0.048340	-0.042978	-0.114746	0.8410665
6. Trunk extension backward	0.049503	0.674032*	-0.244306	0.034945	0.6615572
7. Trunk extension forward	-0.045498	0.129474	0.716497*	-0.177240	0.6044586
8. 800m	0.140234	0.034312	-0.014067	0.004669	0.8084185
9. 1000m	0.074090	0.005652	0.064808	-0.095535	0.9241443
10. 1200m	0.001363	-0.004228	0.136352	-0.108093	0.9043777
11. Shuttle run	-0.015858	-0.075249	0.216181	-0.184373	0.5912244
12. Side steps	-0.089458	0.743209*	0.194393	0.078590	0.6912639
13. Zig zag run	0.099714	0.360174*	0.004192	-0.496949	0.5230129
14. Grip strength	0.053012	0.135712	0.117912	-0.132872	0.8644124
15. Push-up	0.208824	-0.192833	0.573616*	-0.085231	0.6231790
16. Pull-up	0.289131	-0.069834	0.570442	0.068615	0.6928832

Table 4-5 (cont.)

The Rotated Factor Matrix of the Eight Extracted Factors

Variable	P_1	P_2	P_3	P_4
17. Sit-up for 30 sec.	0.253711	0.071675	0.121939	0.081110
18. Sit up for 1 min.	0.251127	0.016340	0.075990	-0.065914
19. Vertical jump	0.608426*	0.223490	-0.019194	0.033887
20. Standing long jump	0.687312*	0.124474	-0.070321	0.044475
21. Triple jump	0.152299	-0.094000	0.088542	0.872774*
22. Softball throwing for distance	0.129249	0.251173	0.053414	0.809326*
23. Handball throwing for distance	0.419803	0.501351*	0.178571	0.084971
24. Shot put	0.078609	0.097501	0.107197	0.126645
25. Baseball throwing for accuracy	0.111980	0.208806	-0.050484	-0.156310
26. Softball throwing for accuracy	0.360716	0.749024*	0.086244	-0.002464
27. Height	0.211708	0.884368*	0.024182	0.075484
28. Weight	0.031822	0.908698*	-0.063784	0.007287
29. Chest Girth	0.065473	0. 836506*	-0.043608	0.084713
Factor Variance (Eigenvalues	5.7513545	4.247065	3.0127565	1.8080244
Percentage of Total Variance	19.84	14.74	10.39	6.23

Table 4-5 (cont.)

The Rotated Factor Matrix of the Eight Extracted Factors

Variance	P_5	P_6	P_7	P_8	Communality (h^2)
17. Sit-up for 30 sec.	0.900767*	-0.059927	0.024493	-0.056319	0.9096985
18. Sit-up for 1 min.	0.909832*	0.052899	0.118986	-0.088433	0.9260301
19. Vertical Jump	o.179091	0.369960	0.139011	-0.156645	0.6344521
20. Standing long jump	0.004343	0.240576	0.317241	-0.152543	0.6766274
21. Triple jump	0.050640	0.050237	0.029283	0.095887	0.8067449
22. Softball throwing for distance	-0.056460	-0.054883	0.0185463	-0.224792	0.8293415
23. Handball throwing for distance	0.115386	0.024743	-0.054172	-0.364007	0.616057
24. Shot put	0.126352	-0.035637	0.065705	-0.746987	0.6225467
25. Baseball throwing for accuracy	-0.50210	-0.113367	0.081149	-0.616425	0.4350587
26. Softball throwing for accuracy	0.180605	0.115709	0.200663	-0.189727	0.8208655
27. Height	-0.003430	0.040673	-0.122334	-0.082532	0.8575337
28. Weight	-0.067104	-0.052111	0.015742	-0.061749	0.8421453
29. Chest Girth	0.045702	0.043021	0.269050	-0.049188	0.7979319
Factor Variance (Eigenvalues)	2.1219458	1.5096796	1.677087	1.631129	1.786682
Percentage of Total Variance	7.32	5.21	5.78	5.62	75.13

Discussion of Data

After the extraction of factors, the meaning of these factors had to be ascertained. To recognize the meaning and property of the factors, the rotated factor matrix must first be observed (Table 4-4). As a rule, the subtests which have zero or near zero loadings on a factor must be identified (23:512-514).

In Table 4-4, seven factors were extracted. On Factor P_1 subtests 1, 2, 3, 4, 5, 11, 19 and 20 have larger factor loadings while others have very small loadings. This means that these subtests can measure the ability that P_1 represented. The remaining subtests marked with "*" in the table can be attributed to their proper factors and can be interpreted in the same way. The following are factors to which the subtests can be attributed:

Factor P_1: 40m, 50m, 60m, 80m, 100m, shuttle run, vertical jump, standing long jump.

Factor P_2: Grip strength, handball throwing for distance (shot put), (baseball throwing for accuracy), softball throwing for accuracy, height, weight, chest girth.

Factor P_3: 800m, 1000m, 1200m.

Factor P_4: Triple jump, softball throwing for distance.

Factor P_5: Sit-ups for 30 seconds, sit-ups for one minute.

Factor P_6: Trunk extension backward, side-steps (zig-zag run).

Factor P_7: Trunk extension forward, push-up, pull-up.

Factor loadings in Table 4-4 marked with " △ " means that the loadings of this subtest on the particular factor are the largest and yet its value is too small and needs further study.

From the foregoing factors, we can infer the properties of the seven factors.

P_1 included three properties; namely, speed (40m, 50m, 60m, 80m, 100m), speedy shift of direction (shuttle run), and elasticity (vertical jump, standing long jump). It was difficult to designate this factor properly. According to its properties, it was designated tentatively as speed-explosive strength.

P_2 included muscular strength (grip strength), coordination (handball throwing for distance, shot put), accuracy (baseball throwing for accuracy, softball throwing for accuracy), size of body (height, weight, chest girth). These four properties make interpretation more difficult. The size of body takes a larger ratio in the variance of P_2. Also, grip strength, handball throwing for distance and others were found to be related with the size of the body. Therefore, P_2 is designated tentatively as "size of body."

P_3 was somewhat simple, including 800m, 1000m, and 1200m. These three items were all related to endurance, and are designated as "endurance."

P_4 included triple jump and softball throwing for distance. The former was attributed to power, while the

latter to coordination. However, upon close scrutiny, the triple jump can be said to involve coordination of the whole body. Furthermore, the loadings of vertical jump, standing long jump, handball throwing for distance, and shot-put on P_4 can be compared; evidently, the latter two (attributed to coordination) have larger factor loadings (i.e., the first two are 0.058329 and 0.072435 respectively, while the latter two are o.146773 and 0.262021 respectively). Therefore, P_4 can be designated tentatively as "coordination."

P_5 included sit-ups for 30 seconds and for 1 minute. These two items were apparently the performance of the strength of body muscle and so P_5 is designated as "the strength of bodily muscle."

P_6 included two properties, flexibility (trunk extension backward) and agility (side-steps and zig-zag run). For this factor, interpretation was also rather difficult. Based upon the property of those three items P_6 was designated as "agility."

P_7 included three items (trunk extension forward, push-up and pull-up). With the exception of trunk extension forward which is attributed to flexibility, these activities are associated with the ability to support the body for continuity of activities; that is, a kind of dynamic strength. Tentatively, they were designated as "flexibility and dynamic strength."

The foregoing designation of factors was based upon the

following assumption: A subject takes a test, and the test result he exhibits comes about from his basic ability. This basic ability is termed as a "factor." Therefore, the foregoing identification and designation of factors are made up theoretically for reference.

We need to explain "communality (h^2)" as shown in Table 4-4. As mentioned before, h^2 is obtained in the following way:

$$h^2_1 = (0.822329)^2 + (0.130137)^2 + \ldots + (-0.030679)^2 = 0.784010.$$

$$h^2_2 = (0.769331)^2 + (0.224772)^2 + - \ldots + (-0.105742)^2 = 0.797357.$$

(The remaining ones can be obtained in the same manner.)

The above calculations mean that 78.40% of the total variance of subtest 1 is attributed to the seven common factors, P_1-P_7, and the remaining 21.60% to other specific components and error components. The sum of communality and specific component is called "reliability."

Finally, an analysis of the last row of Table 4-4, signifies that the seven common factors account for 71.23% and that, of the 71.23 percent, P_1 accounts for 19.81%, P_2 for 15.80% and so on. Hence, the seven factors can be arranged in terms of their importance as P_1, P_2, P_3, P_4, P_5, P_6, P_7.

Table 4-6

Comparison of the Results with Assumptions of the Present Study

Assumption	Result	Consistence
A. From the 29 subtests 7 common factors can be extracted through factor analysis, which account for more than 70% of variance of the total test.	A. The 29 test items after analysis yield 7 common factors, which account for 71.23% of the total variance.	Completely consistent
B. The subtests are attributed to the following factors:	B. The 29 subtests are attributed to the following basic factors:	
(1) P_1: 40m, 50m, 60m, 80m, Shuttle run, vertical jump, standing long jump, triple jump.	(1) Speed-explosive strength: 40m, 50m, 60m, 80m, 100m, shuttle run, vertical jump, standing long jump.	Inconsistent
(2) P_2: 800m, 1000m, 1200m.	(2) Endurance: 800m, 1000m, 1200m.	Consistent
(3) P_3: Sit-ups, 30 seconds; Sit-ups, 1 minute.	(3) Strength of bodily muscle: Sit-ups, 30 seconds; Sit-ups, 1 minute.	Consistent
(4) P_4: Push-up, Pull-up, Trunk extension forward.	(4) Flexibility and Dynamic strength: Push-up, Pull-up, Trunk extension forward.	Consistent
(5) P_5: Handball throwing, Softball throwing, Shot-put, Baseball throwing marks, Softball throwing marks.	(5) Coordination, Triple jump, Softball throwing.	Inconsistent
(6) P_6: Height, Weight, Chest girth, Grip strength.	(6) Size of body: Grip strength, handball throwing, (Shot-put), (Baseball throwing marks), Softball throwing marks, Height Weight, Chest girth.	Inconsistent
(7) P_7: Side-steps, Zig-Zag run, Trunk extension backward.	(7) Agility: Side-step, Zig-Zag run, Trunk extension backward.	Consistent

The assumptions of the present study are formulated on the basis of the Chinese Education Ministry Tryout Test and on the analysis of part of the interrelationships of the subtests. As a whole, the assumptions and the findings of this study are consistent, though some differences exist. The re-organization of some subtests are as follows:

(1) Triple jump under P_1 and softball throwing under P_5 are grouped under "Coordination."

(2) All the test items of P_5 except Softball Throwing and all the items of P_6 are grouped under "Size of body."

Comparison of the Results of the Study with Those Published of Other Scholars

Scholars in other countries have done a considerable amount of study in physical fitness, and those studies done by factor analysis are cited in the following for comparison.

Comparison of the Results of This Study with Literature of Other Countries

Scholar	Structure of Physical Fitness
C.H. McCloy	1. Muscular Strength, 2. Speed, 3. Coordination of Large Muscle
L.M. Jones	1. Coordination of Large Muscle, 2. Size of Body
E. McCloy	1. Muscular Strength, 2. Speed, 3. Weight
A. J. Wendler	1. Muscular Strength, 2. Speed, 3. Ability to Learn Athletics, 4. Feelings--Athletic coordination
L.M. Roulnac	1. Speed, 2.Coordination, 3. Endurance, 4. Weight
L. A. Larson	1. Dynamic Strength, 2. Muscular Strength measured by meter, 3. Coordination of Large Muscle, 4. Strength of Abdominal Muscle
T. K. Cureton	1. Equilibrium, 2. Flexibility, 3. Muscular Strength, 4. Power, 5. Agility, 6. Endurance
(U.S.A.) Independent factors with a cumulative frequency of five or more	1. Muscular Strength, 2. Speed, 3. Dead Weight, 4. Coordination of Large Muscle, 5. Ability to learn Athletics, 6. Dynamic Muscular Strength

Factor identified as a result of this study	1. Speed-explosive Strength, 2. Size of of Body, 3. Endurance, 4. Coordination, 5. Strength of Bodily Muscle, 6. Agility, 7. Flexibility and Dynamic Strength

As mentioned before, designation of factors is based on theories. Although different scholars obtained a similar factor matrix, they defined differently the operational definition of "physical fitness," and the items for analysis also differed greatly. For these reasons, the basic factors through analysis were inconsistent. On the previous page it can be seen that the number and designation of factors extracted by various investigators differ from one another. If we do not inquire into what the factor contains, it is difficult for us to make a comparison. Therefore, it is fitting for Chinese investigators to use factor analysis to determine the frequently occurring factors as the basic factors of physical fitness.

Comparison of the Results of This Study with the Chinese Education Ministry Tryout Test

The basic factors assumed in the Chinese Education Ministry Tryout Test seem acceptable to the people of China. However, a comparison of the results of the present study with the results of the Education Ministry Tryout Test identifies other factors not included in the original test. A comparison of these factors follows:

Comparison of the Results of This Study with the Education Ministry Tryout Test

The Tryout Test	Results of This Study
I. Speed Factor: Includes the 40, 50, 60, 80, and 100 meter dashes	I. Speed-explosive strength Factor: Includes the 40, 50, 60, 80 and 100 meter dashes, Shuttle run, Vertical jump, Standing long jump.
II. Flexibility Factor: Includes 1. Trunk extension backward, 2. Trunk extension forward.	II. Endurance Factor: Includes 1. 800m, 2. 1000m, 3. 1200m
III. Endurance factor, includes: 1. 800m, 2. 1000m, (Boys of junior high school)	III. Strength of bodily muscle Factor: Includes 1. Sit-up 30 second, 2. Sit-up for 1 minute
IV. Agility Factor: 1. Shuttle run, 2. Side-steps, 3. Zig-zag run	IV. Flexibility and dynamic strength Factor: Includes 1. Push-up, 2. Pull-up, 3. Trunk extension forward
V. Strength of upper extremity Factor: Includes 1. Grip strength, 2. Push-up, 3. Pull-up	V. Coordination Factor: Includes 1. Triple jump, 2. Softball throwing
VI. Bodily strength Factor: Includes 1. Sit-ups for 30 seconds, 2. Sit-ups for 1 minute	VI. Size of body Factor: Includes 1. Grip strength, 2. Handball throwing, 3. Shot-put, 4. Baseball throwing marks, 5. Softball throwing marks, 6. Height, 7. weight, 8. Chest girth
VII. Power Factor: Includes 1. Vertical jump, 2. Standing long jump 3. Triple jump	VII. Agility Factor: Includes 1. Side-steps, 2. Zig-zag run, 3. Trunk extension backward

The Tryout Test (cont'd)	Results of This Study (cont'd)
VIII. Coordination Factor: Includes 1. Softball throwing, 2. Handball throwing	
IX. Accuracy Factor: Includes 1. Baseball throwing marks, 2. Softball throwing marks	

As can be seen above only two factors of this study, "Endurance" and "Strength of bodily muscle," cover the same items as that of the Education Ministry Tryout Test; all the others differ greatly (e.g. trunk extension forward and trunk extension backward are not under the same factor; triple jump and vertical jump not under the same factor; softball throwing and handball throwing not under the same factor). It is evident that many traditional concepts may need to be modified.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

This investigation was designed to explore the basic elements of physical fitness which will reveal source materials for the construction of physical fitness tests for the Republic of China.

Subjects participating in this study were randomly selected from two junior high schools in Kaohsiung City, Taiwan. A representative sample of fifty male students was randomly chosen from each school which comprised a total of 100 seventh-grade males, aged twelve to thirteen years. Eighty subjects completed the 29 subtests.

The 29 subtests administered to each of the students were selected by the investigator and were an adaptation of tests devised by the Chinese Education Tryout Test and the International Committee on the Standardization of Physical Fitness Tests. Raw data scores for each of the students performance were recorded in matrix form and a factor analysis was performed by computer with reference to the available scores. The factor analysis procedure utilized the Harman's Minres (Minimum Residual Factor Analysis), Kaiser's Varimax for analytic rotation of factor axes, and R. B. Cattell's "Scree Test" which determined the

number of factors to be used.

The 29 subtests were completed over a two-day period from December 13-14, 1979. A booklet showing the testing procedure was prepared and the teachers used to administer the test were trained. All testing events were held outdoors at Jui-Fong Junior School. A total of 14 events or subtests were held on the first day while the remaining 15 were administered on the following day. Teachers recorded each student's performance in each of the events. Two weeks later, these same pupils were asked to repeat the 29 subtests again, over a two-day period.

Upon completion of the testing procedures, raw data scores were collected for each participant in each of the 29 subtests. Raw test scores were recorded in matrix form and a factor analysis was performed by computer with reference to the available scores.

This study revealed the presence of seven basic factors which comprised physical fitness: speed-explosive strength, size of body, endurance, coordination, strength of bodily muscle, agility, and flexibility-dynamic strength. It was discovered that there was an independent relationship between each of the seven factors. Therefore, it was concluded that students who scored high in one aspect of physical fitness may not score high on other aspects of physical fitness.

Conclusions

(1) The basic factors that make up physical fitness are seven: speed-explosive strength, size of body, endurance, coordination, strength of bodily muscle, agility, and flexibility-dynamic strength. These seven basic factors can account for more than 70 percent of the total variance of physical fitness. At this point, the results of this study are consistent with hypotheses.

(2) The factors to which the physical fitness test items are attributed are listed below. The results agree with most part of the hypotheses, but "coordination" and "size of body" do differ from the hypothesis. As compared with the Chinese Education Ministry Tryout Test, all factors but two differ greatly. Those two identical factors are "endurance" and "strength of bodily muscle."

(The following subtests are arranged in sequence of the values of their loadings on the factor):

(I) Speed-explosive strength: 100m, 40m, 80m, 60m, 50m, Standing long jump, Shuttle run, Vertical jump.

(II) Size of body: Height, Weight, Grip strength, Chest girth, Soft-ball throw for accuracy, Handball throw for distance, (Baseball throw for accuracy), (Shot-put).

(III) Endurance: 1000m, 1200m, 800m.

(IV) Coordination: Triple jump, Softball throw

for distance.

(V) Strength of bodily muscle: Sit-ups for 1 minute, Sit-ups for 30 seconds.

(VI) Agility: Side-steps, Trunk extension backward, (Zig-zag run).

(VII) Flexibility-dynamic strength: Trunk extension forward, Push-ups, Pull-ups.

(3) The basic factors which account for a larger percentage of the total variance are "speed-explosive strength" (19.91%), "size of body"(15.80%), "endurance" (10.51%), whereas the others in sequence are "strength of bodily muscle" (7.42%), "coordination" (6.50%), "flexibility-dynamic strength" (5.83%), "agility" (5.32%).

(4) The part (h^2) of the subtest variances accounted for by the above seven common factors are shown as follows: (" * " indicates low communality, i.e. validity of the subtest is too low.)

40m	:0.784010	Pull-ups	:0.643075
50m	:0.797537	Sit-ups for 30 seconds	:0.891132
60m	:0.846081	Sit-ups for 1 minute	:0.919421
80m	:0.787712	Vertical jump	:0.627499
100m	:0.832336	Standing long jump	:0.663905
Trunk extension backward	:0.653280	Triple jump	:0.762585
		Softball throwing for distance	:0.828070
Trunk extension forward	:0.592348	Handball throwing for distance	:0.580412

800m	:0.784788	Shot-put	:0.293760*
1000m	:0.919924	Baseball throwing for accuracy	:0.198287*
1200m	:0.902472		
Shuttle run	:0.575679*	Softball throwing for accuracy	:0.815895
Side-step	:0.688562	Height	:0.842679
Zig-zag run	:0.408390	Weight	:0.819415
Grip strength	:0.853196	Chest girth	:0.736148
Push-up	:0.608779		

Recommendations

The following suggestions are based on the foregoing conclusion:

(1) To conduct the similar investigation in a large scale sampling: This study is the first of its kind employing factor analysis to investigate the structure of physical fitness. The findings have contradicted to some of our traditional concepts (e.g. "Trunk extension forward" and "Trunk extension backward" are not under the same factor, whereas "Softball throwing" and "Triple jump" are under the same factor). The writer of the present study could not afford financially a study with a larger sample than the present one, which included only the first-year boy students of junior high schools in Kaohsiung, and could not include more test items that usually employed in measurement of physical fitness. Therefore, the findings of this study is limited in inference. The writer would like to make a

suggestion that Chinese scholars or research institutes should conduct a study of physical fitness of the students of all school levels with more extensive test items and with the collected data to analyze the basic factors of physical fitness. It may confirm the findings of this study, also it may promote the academic study in the field of physical fitness.

(2) Based on the findings of this study, it is suggested that, for the junior high school students, the testing result in the following test items can be used for evaluation of the students' physical fitness.

1. 100m dash, 2. Height, 3. 1000m run, 4. Softball throwing, 5. Sit-ups for 1 minute, 6. Side-steps, 7. Push-ups.

The criterion for choosing the above items is such that, under each factor, the item with higher factor loadings and larger communality is to be chosen.

(3) It was found that the relationship between these seven factors was negligible. Those students who scored high on certain aspects of physical fitness may not score high on others. Therefore, "physical fitness in general" cannot be used as criteria for evaluating individual difference of student's physical fitness. Some students who perform badly in one aspect may do well in other aspects. The prevailing training of "athletic stars" in schools is apparently a misconception. We should provide a program

for all to enable every student to develop his physical fitness to their utmost.

(4) The present study is the first factor analysis study completed in the Republic of China and further study is needed to confirm the findings.

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APPENDIX

APPENDIX A

Raw Scores for All Subjects on Each Variable of the 29 Subtests

SUBJECTS	SUBTESTS: 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
1	7''2	8''8	10''9	14''3	18''1	25	11	286	358	426	12''0	30	7''3	12	25	2	17	29	36	1.6	5.0	13	15	2	5	3.6	129	28.0	60.7
2	7''0	8''6	10''6	13''4	17''0	38	20	301	373	442	12''0	38	7''4	13	11	1	9	17	32	1.8	5.3	26	12	5	5	3.8	134	29.0	67.5
3	6''3	8''4	9''5	12''8	15''2	37	25	301	360	413	10''5	34	7''2	20	8	1	12	24	31	1.8	5.2	26	12	7	8	3.8	136	32.0	74.4
4	7''1	8''7	10''1	13''4	17''1	35	12	297	370	438	11''5	35	6''8	18	21	4	15	27	34	1.9	5.6	30	17	4	8	4.0	137	35.2	69.5
5	7''2	8''8	10''9	14''3	18''1	32	18	178	230	279	12''7	38	7''1	20	20	5	16	30	43	2.3	6.0	34	20	6	6	4.8	139	33.0	75.0
6	7''0	8''7	10''3	13''9	17''7	35	13	295	365	422	12''3	33	6''7	18	23	3	26	41	40	1.8	4.9	20	13	5	7	4.8	139	34.0	71.5
7	7''2	9''5	10''8	14''8	17''8	35	16	306	381	456	12''2	41	7''0	23	23	4	13	25	43	1.9	5.6	37	21	8	3	5.1	140	33.5	69.4
8	7''0	8''8	10''1	13''9	16''7	39	16	303	377	449	12''3	40	7''2	25	7	2	3	4	36	1.8	5.1	27	14	4	2	5.1	145	41.0	70.2
9	7''0	8''8	10''5	15''9	17''0	30	15	305	379	453	11''6	40	6''7	19	19	4	15	28	35	1.7	5.0	24	12	4	5	4.7	143	33.1	70.1
10	8''0	10''2	11''3	15''6	18''9	31	17	338	415	492	13''2	36	7''1	19	17	5	18	32	47	2.9	6.3	32	18	3	6	5.0	142	32.5	73.0
11	7''2	9''5	10''9	14''7	17''9	42	0	327	399	466	11''7	40	6''9	16	21	3	18	24	36	1.8	4.7	20	21	4	5	3.7	141	28.5	60.6
12	7''1	8''8	10''5	14''0	16''9	25	12	311	386	450	12''0	35	7''3	21	34	10	20	35	30	1.8	5.5	39	20	6	10	5.2	145	34.5	73.5
13	7''2	8''6	10''3	14''6	17''0	35	20	329	404	473	12''5	37	7''1	24	27	7	15	26	37	1.8	5.1	32	18	5	8	4.5	142	34.3	75.0
14	7''1	8''7	10''8	14''7	18''5	35	13	328	403	472	12''4	35	7''5	23	21	2	13	27	35	2.0	5.0	16	20	2	9	4.0	145	38.3	70.1
15	8''1	10''5	11''3	16''1	19''7	25	14	330	405	474	12''4	39	7''6	22	15	5	17	27	42	2.0	5.4	20	15	6	3	5.4	145	33.0	73.5
16	7''8	9''8	11''1	14''6	18''8	42	15	323	392	458	12''5	38	7''1	22	19	4	23	36	40	1.9	5.8	32	20	6	2	4.8	143	35.5	69.8
17	7''3	9''5	10''9	14''7	18''8	35	20	337	414	491	12''5	39	7''6	25	30	4	13	24	34	2.0	6.1	31	16	4	10	5.7	144	38.0	78.5
18	8''0	9''5	10''9	16''1	18''8	35	15	282	348	381	12''5	32	7''1	31	22	3	15	24	34	2.0	5.5	25	16	2	5	5.7	153	42.5	77.7
19	8''0	9''6	11''2	15''0	19''9	34	15	290	352	376	12''5	34	6''7	25	17	5	20	28	36	2.2	5.2	32	21	4	9	5.3	148	40.0	70.2
20	7''4	9''5	11''0	15''1	19''1	32	15	325	396	462	12''5	36	7''8	22	32	4	16	25	33	2.0	5.3	34	23	7	5	4.9	147	34.0	65.9
21	7''8	9''5	11'0	15''3	19''1	27	13	302	371	441	12''1	37	7''8	26	20	2	11	18	37	1 '	5.3	34	14	4	9.	4.9	156	65.5	70.2
22	7''3	9''5	10''7	14''9	16''9	37	11	295	364	428	11''5	39	7''5	19	15	1	16	30	42	1.8	5.6	28	21	4	6	4.1	149	34.5	70.0
23	7''1	9''5	11''1	14''9	18''3	41	16	320	398	479	12''3	41	7''6	31	33	6	17	32	44	2.2	5.3	26	12	4	11	6.4	148	40.0	77.7
24	7''2	8''7	10''0	13''9	16''8	38	14	324	397	467	11''0	37	7''3	23	30	2	16	28	34	1.8	4.9	23	20	6	7	4.1	148	38.0	70.0
25	7''2	9''6	10''9	14''7	18''8	36	29	331	408	472	11''9	38	7''9	26	26	4	16	30	39	1.9	5.7	36	20	3	7	6.1	149	38.0	80.5
26	7''2	9''4	10''9	14''5	17''8	38	21	289	351	378	12''6	35	7''3	26	18	4	22	35	46	1.9	5.6	40	17	5	7	5.5	149	47.5	80.7
27	7''3	9''4	10''9	16''8	18''0	25	15	332	393	457	12''5	35	6''6	19	25	4	11	18	40	1.9	5.5	31	21	4	8	4.2	151	38.5	74.6
28	7''2	9''5	10''3	14''7	17''8	32	14	315	382	445	13''3	34	7''6	28	26	3	14	27	42	1.9	5.4	33	18	6	6	4.5	150	48.5	81.2
29	7''0	9''2	9''6	13''3	15''9	30	17	310	381	446	12''1	37	8''0	21	18	2	16	23	38	2.0	5.6	26	20	9	10	4.2	144	31.5	67.0
30	8''2	9''7	11''0	15''9	19''0	31	24	320	396	465	12''9	41	7''9	28	43	7	20	32	43	2.3	6.0	40	20	4	4	6.7	152	36.5	72.0

APPENDIX A

Raw Scores for All Subjects on Each Variable of the 29 Subtests (cont.)

	SUBTESTS:																											
SUBJECTS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
31	8"1	9"5	10"9	15"0	19"0	33	14	320	392	456	13"0	41	7"2	23	21	3	16	20	35	1.9	5.8	21	20	3	5	4.4	154	39.5	76.0
32	6"3	9"7	10"3	13"0	15"8	39	13	321	394	451	11"5	39	7"3	24	14	1	14	16	30	1.7	5.2	30	17	5	8	4.3	151	40.5	74.0
33	7"3	9"5	10"9	15"1	18"8	33	8	342	419	499	12"5	39	7"6	27	32	7	23	27	50	2.2	6.4	30	20	5	8	5.8	152	38.5	76.9
34	8"1	10"5	11"5	15"6	19"4	35	4	323	397	467	12"9	38	7"7	23	22	2	20	25	45	2.0	5.9	36	25	5	8	5.2	155	39.0	75.5
35	7"9	9"7	10"9	15"3	19"4	40	13	333	409	487	12"9	34	8"0	32	17	5	8	12	46	2.0	5.8	43	24	7	10	5.9	155	39.5	73.6
36	7"3	9"5	11"1	15"6	18"4	35	13	316	384	452	12"5	36	7"4	23	25	3	22	28	38	2.0	5.8	28	22	9	8	5.0	150	35.5	72.7
37	8"0	9"7	11"0	15"3	17"9	30	14	313	387	436	12"2	30	7"1	29	30	5	30	37	36	2.0	5.7	21	20	5	10	6.3	158	45.0	76.0
38	7"3	9"5	10"9	15"1	18"8	30	18	344	420	493	13"3	35	7"8	29	25	3	26	35	38	2.0	6.0	32	25	8	7	5.7	154	41.0	75.2
39	7"3	9"6	10"7	15"0	17"0	38	13	306	364	420	12"5	34	7"2	24	20	1	9	13	36	1.8	5.5	38	25	5	7	5.1	158	44.5	74.0
40	7"4	9"5	10"9	15"0	17"7	31	17	321	395	469	11"9	32	7"6	29	27	2	20	21	45	2.0	6.5	52	30	7	5	5.1	160	48.0	79.0
41	8"2	10"5	11"9	15"6	19"6	34	20	356	438	514	12"9	35	7"9	35	31	4	22	29	42	2.0	6.3	48	29	9	11	8.9	164	50.5	84.0
42	8"1	10"4	11"8	15"5	19"5	38	17	362	445	524	13"4	30	7"9	31	32	3	26	44	45	2.0	6.3	39	25	7	8	7.8	161	53.5	82.0
43	7"4	9"7	11"3	15"3	18"9	27	14	321	393	470	12"3	37	7"6	30	30	3	17	30	34	2.0	6.0	41	20	7	7	5.2	157	44.0	76.3
44	7"4	9"8	11"4	15"8	20"1	42	11	354	429	497	12"9	38	8"1	22	26	3	20	32	43	2.2	6.8	30	19	9	7	4.9	136	29.5	64.0
45	7"0	9"5	10"8	13"0	17"8	32	14	259	334	395	11"5	34	7"7	16	16	0	14	33	31	1.6	4.9	29	15	7	9	4.0	138	31.0	72.0
46	8"2	9"6	9"5	13"0	16"4	32	12	307	382	451	11"5	31	6"0	20	26	1	7	9	29	1.8	5.4	26	15	6	6	3.5	136	30.0	69.0
47	7"8	9"8	11"0	15"2	18"9	36	14	335	410	470	12"7	37	8"3	19	19	3	16	29	41	2.1	5.9	27	17	5	5	4.2	140	29.5	72.0
48	7"0	8"7	10"5	14"4	17"4	36	12	302	377	401	11"3	36	7"6	20	11	2	16	28	35	1.9	5.1	29	20	3	6	4.7	140	33.0	71.0
49	7"3	8"8	10"7	14"0	17"9	33	8	325	400	458	11"7	33	6"8	17	17	2	17	29	35	1.9	5.8	21	13	2	2	4.1	139	32.0	65.0
50	7"1	8"9	10"0	13"9	16"9	39	15	315	390	456	11"7	41	7"9	20	16	1	16	25	33	1.8	5.3	27	18	1	3	3.9	141	30.0	67.0
51	6"4	8"6	10"3	13"7	17"4	36	12	314	389	453	11"1	36	7"0	20	25	2	15	25	30	1.5	4.8	18	16	4	5	4.4	140	33.5	70.0
52	7"2	9"2	10"8	13"0	17"9	45	16	305	380	419	12"5	36	7"7	18	20	3	21	34	37	1.7	5.1	28	18	4	6	3.1	141	33.5	68.0
53	7"0	8"8	10"6	13"6	17"4	37	19	348	423	493	11"6	35	7"4	18	25	2	15	27	37	1.9	4.2	21	17	5	7	4.5	141	31.8	65.0
54	7"3	9"6	11"3	15"8	19"0	32	19	349	424	490	12"7	32	7"2	20	20	3	15	27	40	1.9	6.1	28	15	8	7	4.0	140	33.0	72.0
55	7"2	9"3	10"7	15"1	18"0	28	8	309	384	449	11"5	30	7"3	20	5	2	14	23	34	1.6	4.2	18	14	4	3	4.0	143	33.0	67.0
56	7"5	9"7	11"1	15"7	18"9	42	17	326	401	459	12"5	37	7"6	28	22	3	13	23	44	2.1	6.1	30	18	8	7	4.9	143	33.0	70.0
57	7"0	8"7	10"4	14"3	17"5	37	14	319	394	457	12"4	36	7"9	20	22	4	17	27	28	1.8	5.5	39	21	6	5	5.0	144	33.5	71.0
58	7"5	9"5	11"6	15"1	18"8	33	16	337	414	484	12"6	31	7"8	26	17	4	21	35	35	1.8	5.2	35	18	8	0	5.1	146	38.0	76.0
59	7"2	8"8	10"8	15"7	17"7	39	7	332	385	383	11"0	34	7"1	24	6	1	18	28	28	1.7	5.1	25	16	6	9	4.9	152	31.5	71.0
60	7"2	8"8	10"8	14"6	18"0	42	14	326	409	483	12"6	37	8"2	22	15	2	19	32	43	1.8	5.5	31	22	7	8	5.2	146	38.0	70.0

APPENDIX A

Raw Scores for All Subjects on Each Variable of the 29 Subtests (cont.)

SUBJECTS	SUBTESTS: 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
61	6"3	8"5	10"1	13"1	16"9	36	16	264	319	310	11"8	37	7"4	17	13	1	14	21	37	1.7	5.1	25	15	1	5	3.8	146	31.5	64
62	7"0	8"5	10"1	13"3	17"1	37	10	260	312	303	11"6	40	7"3	24	6	1	24	37	38	1.7	5.2	23	14	6	7	4.7	145	38.0	72
63	7"1	8"7	10"6	14"4	17"8	30	21	328	403	467	10"1	35	7"1	21	23	2	22	36	46	1.7	5.9	30	14	6	4	4.2	146	34.0	69
64	7"1	8"6	10"1	13"9	16"9	30	13	329	408	473	12"5	36	6"8	19	23	1	17	22	33	1.8	5.2	28	18	3	6	3.7	147	30.0	66
65	7"2	9"2	10"7	14"7	16"9	30	14	314	388	463	12"4	37	7"6	23	36	2	16	23	40	1.6	5.2	21	14	1	6	4.4	150	37.5	73
66	6"0	7"2	8"7	11"1	13"9	43	17	245	295	266	11"0	34	7"1	25	10	0	5	5	26	1.6	4.8	23	13	5	2	5.5	149	57.5	90
67	8"0	9"7	11"1	15"0	18"9	28	12	295	328	385	12"5	37	7"4	21	20	3	18	30	33	1.6	5.1	35	20	3	8	4.8	148	35.5	73
68	7"2	9"0	10"3	14"0	16"9	42	14	317	395	473	12"3	44	7"5	20	32	3	21	35	33	1.8	5.2	28	18	6	6	4.7	147	38.0	73
69	7"0	8"8	10"1	13"8	16"8	22	13	312	388	468	12"4	39	7"4	28	27	1	16	27	30	1.8	4.9	27	17	3	5	4.3	149	44.5	79
70	7"4	9"6	10"8	14"8	18"0	37	12	316	393	458	12"4	35	7"5	24	23	1	21	36	38	1.8	5.5	25	16	3	4	4.6	151	38.5	69
71	8"1	10"3	12"1	16"9	19"9	34	13	355	445	528	12"9	37	7"5	31	27	9	26	46	41	2.0	6.5	41	28	5	2	6.0	150	42.5	84
72	8"2	10"3	12"1	16"8	19"8	36	15	536	419	498	12"3	38	7"5	30	27	6	24	38	39	2.0	6.2	24	24	6	5	6.2	148	37.2	75
73	6"9	8"8	10"2	13"9	17"4	27	19	271	328	390	11"7	36	7"1	29	12	2	14	21	32	1.7	5.2	23	15	4	5	5.0	151	39.5	69
74	6"8	8"6	10"1	12"9	17"4	34	13	274	332	398	12"0	35	7"4	27	13	1	14	26	33	1.8	5.5	37	21	7	5	5.6	152	40.0	72
75	7"3	9"5	10"7	15"0	17"9	35	15	268	312	295	11"5	40	7"4	29	17	3	20	32	42	2.1	5.8	18	15	5	6	5.0	154	38.5	70
76	7"2	9"7	10"9	14"6	18"9	37	17	314	390	468	11"6	41	7"4	31	18	3	16	31	43	1.9	5.5	28	17	4	3	6.0	154	41.5	75
77	8"1	9"7	12"2	16"9	21"0	23	17	316	394	457	12"9	42	7"5	43	31	5	19	40	52	2.4	7.0	47	34	9	10	8.5	161	55.0	87
78	7"2	9"7	11"1	14"0	18"7	34	11	309	373	442	12"1	39	7"6	29	18	1	12	25	37	2.1	5.9	30	21	5	11	5.9	161	46.5	76
79	7"1	9"4	10"6	14"8	17"7	39	10	308	368	433	11"1	37	7"4	30	11	2	17	27	41	2.1	6.2	30	26	3	6	6.7	163	45.0	80
80	7"2	9"7	10"8	14"7	18"8	50	17	293	345	423	11"7	43	7"3	29	17	2	15	28	50	2.1	5.6	34	27	5	9	6.7	172	55.5	90

APPENDIX B

TEST MANUAL
(Translated from Chinese Test Manual by Chen-Hsing Huang)

I. Speed

Equipment and Facilities

The following equipment and facilities are needed:

1. A Track with lanes 1.25 meters wide.
2. Finish line posts
3. Measuring tape
4. Whistle
5. Starting gun
6. Ten stop watches (.1 second accuracy)
7. Signal flag or whistle
8. Limestone

Methods

1. The starting line should be marked and finish lines for the 40, 50, 60, 80, and 100 meter dashes should also be marked.

2. Timekeepers should stand at each finish line and record the time at each distance.

3. The starter stands three meters before the starting line and contacts the timers with a signal flag or whistle.

4. The starter uses the commands "are you ready" and then fires the gun.

5. Each student will take the tests two times with at least 45 minutes between tests.

Scoring

1. The scores are to be recorded to the nearest tenth of a second.

2. The best of the two times will be used for the score.

Rules

1. Students taking the test are to wear regular gym

shoes without spikes.

2. Students may run barefoot.

3. No starting aids are allowed.

II. Flexibility

Trunk Extension Backward

Equipment and Facilities

1. Thin vinyl plastic sheets (4 in. x 6 in.)

2. Measuring stick (ruler) or compass.

3. Chalk.

Methods

1. Students being tested should be face down on their stomach and clasp their hands behind their back. The legs are spread 45 cm in width.

2. The Test inspector stands in the middle of the person's legs and pushes down on the upper part of the legs.

3. On the command to start the student should move the chest upward keeping the chin tucked in until the test is over.

4. Using a measuring stick, the inspector measures the height of the chin perpendicular to the floor.

Scoring

1. Only one test will be recorded.

2. The heighth will be measured in centimeters.

Rules

1. The inspector cannot push the student's hips.

2. The chin should remain tucked in during the Test and not extended.

Trunk Extension Forward

Equipment and Facilities

1. Need chairs or bench 50 centimeters high to stand on.

2. Measuring stick at least 100 centimeters long.

Methods

1. Students stand on the chair with feet together facing the front.

2. The student should bend forward keeping the hands parallel and fingers placed on the measuring stick. The fingers slide down the stick as the head is lowered between the legs which cannot be bent.

3. Each student will be tested two times.

Scoring

1. The inspector will read the number in centimeters at the fingertips.

2. The best score from the two tests will be recorded.

3. The results will be recorded in centimeters and rounded to the nearest tenth.

Rules

1. The student is to gradually bend the trunk forward without using forceful movements.

2. The knees must be kept straight during the test.

III. Endurance

The endurance test used in the junior high school was the 800, 1000, and 1200 meter run.

Equipment and Facilities

1. A 400 meter track properly marked with a start and finish line.

2. Limestone for marking

3. A whistle

4. A signal flag

5. Several stop watches

6. Numbered pennants for the students to wear while running.

Method

1. The starter stands three meters in front of the starting line

2. The students stand three meters behind the line. On the command "are you ready," the student steps toward the line. The student starts the run on the command of "go" or the whistle.

3. A timekeeper stands at each finish mark (800, 1000, 1200 meters) to indicate the times

Scoring

1. The timekeeper reads the time for each student to the nearest second and the inspector records the time.

Rules

1. The weather should be mild, not hot or humid.

2. The track should be flat and clean.

IV. Agility

Side-Steps

Equipment and Facilities

1. Use a flat concrete floor

2. A center line with two parallel lines one meter from the center one used.

Method

1. Students stand on the center line

2. Start by making a step with both feet to the right

over the line, then return to the center and make the same step to the left and repeat for 20 seconds.

Scoring

1. Each time the student passes a parallel line (over and back) one point is scored for each crossing.

Rules

1. Use a non-slippery floor
2. No points are scored when a foot touches the parallel line or does not stand on the center line.

Zig-Zag Run

Equipment and Facilities

1. Use five chairs
2. Limestone for marking
3. Tape measure
4. Stop watch
5. Baseball court (concrete)

Method

1. The chairs are placed 2.5 meters apart with the first chair 2.5 meters from the start.
2. Student stands behind the starting line.
3. The starting signal is "are you ready," "go".
4. The student runs a zig-zag route around the five chairs and finishes at the starting line.
5. The student is to take the test one time.

Scoring

1. The score is the time elapsed for the run.
2. Time will be measured to the nearest tenth of a second.

Rules

1. Student must not touch the chairs.

Shuttle Run

Equipment and facilities

1. Need a flat field marked with two parallel lines ten meters apart. Two circles 50 centimeters in diameter, one drawn beyond each line.

2. Two pieces of 5x5 cm wooden blocks, one placed in the circle.

Method

1. The starting point is the line.
2. The starter says "are you ready," and says "go" or blows a whistle.
3. The student runs to the other line and picks up one block and brings it back to the other circle and places it down. The student returns to get the second block and finishes by running across the line with the block.

Scoring

1. Time is recorded to the nearest tenth of a second.

2. The test is administered two times for each student. The best time is used for the score.

Rules

1. The surface should be flat but not slippery.

2. If the block is thrown into the circle, the test should be taken over.

V. Strength of Upper Extremity and Trunk

Grip Strength

Equipment

1. A Smedley Dynamometer for grip strength

2. $MgCO_3$

3. Table and Chairs

Method

1. Instrument should be adjusted so it may be gripped by the fingers and palm of the hand.

2. When holding the instrument, the hand of the gauge should point outward.

3. Stand with the body straight, feet open, and hands to the side.

Scoring

1. The student uses the dominant hand and grasps the instrument two times with a five minute interval.

2. The results are recorded in kilograms.

Rules

1. The dynamometer must be squeezed only by the hand without the aid of shaking or touching the body.

Push-ups

Equipment and facilities

1. Need mats or vinyl cloth.

Method

1. Assume a front leaning rest position with the hands directly on line with the shoulders and legs extended behind.

2. The arms should be perpendicular to the ground with the neck, back, legs, and feet straight.

3. The elbows are bent until the chest nearly touches the ground. The abdomen should not touch.

4. The only movement is the arms as they are bent at the elbow.

Scoring

1. Each person takes the test one time.

2. Scores will be recorded by the number of pushups completed.

Rules

1. The head, shoulders, back, and hips should be formed as a slope.

Sit-ups

Equipment and facilities

1. Use mats or vinyl cloth
2. Stop watch

Method

1. The subject lies on the mat with feet spread 30 centimeters with the knees bent 80^{o}.

2. Hold the hands in back of the neck.

3. The inspector examines the knees to be certain the feet are kept in touch with the floor.

4. The command to start is initiated by the signal "Are you ready?" The subject moves on command to touch the elbows on the knees and return to the original position.

Scoring

1. Record the number of situps made in 30 seconds and also 1 minute.

2. The test is administered once for each time limit.

Rules

1. Do not push off the floor with the elbows.

2. Keep hands behind the neck during the test.

3. The knees must be bent to 80^{o} with the feet held to the floor.

4. The back should touch the floor to complete one situp.

5. If necessary, short stops are allowed.

6. More than one student may be tested at a time.

Pull-ups

Equipment and Facilities

1. Pull-up bar
2. Stool
3. Mg C_{O3}

Method

1. Grasp the bar with the palms away. (Positive Grip)

2. The distance between the hands is the same as the width of the shoulders.

3. After gripping the bar the student will hang until ordered to start. The pull-up is accomplished when the chin is placed over the bar.

4. The student must return to the original position with the arms straight.

Scoring

1. Each time the chin goes over the bar counts one time.

2. Test is administered once.

Rules

1. Kicking and swinging is not allowed. The examiner can only help correct the position of the body.

2. The student must cease taking the test when he stops for two seconds.

3. The height of the bar should be higher than the tallest students.

4. More than one student can take the test at one time.

VI POWER

Vertical Jump

Equipment and facilities

1. Vertical wall
2. Colored chalk
3. Measuring stick
4. A line 20 centimeters and parallel to the wall.

Method

1. The student reaches up and makes a mark on the wall with the tips of the fingers.

2. The student crouches down (bends knees), swings the hands and jumps up and marks the wall again.

3. The student cannot touch the wall with both feet. However, one foot may touch.

Scoring

1. Measure the distance between the standstill reach and the point reached when jumping.

2. Measurements will be made in centimeters.

Rules

1. The feet must be placed squarely on the floor.

Standing Long Jump

Equipment and facilities

1. Need a flat area either a non-slippery floor or ground
2. Limestone
3. Measuring stick

Method

1. Student's toes should be behind the starting line and standing flat footed when ready to jump.

2. Student may swing the arms back and forth when jumping.

Scoring

1. Each student is tested two times and the best score is recorded to the nearest centimeter.

Rules

1. Students may use regular gym shoes without spikes.
2. The distance is measured from the starting line to the nearest spot where the back of the foot (heel) touches the ground.
3. If the student falls when landing they should retake the test.

Triple Jump

Equipment and Facilities

1. Need a flat non-slippery field.
2. Limestone
3. Measuring tape

Method

1. Starting from a standing position behind the line the student hops on one foot, steps to the other, and then jumps to both feet.
2. The measurement is from the starting line to the nearest point where the body touches the ground.

Scoring

1. Each student is tested two times once the best score is recorded in centimeters.

Rules

1. Soft sole shoes (no spikes) or barefoot are allowed.
2. The jump must be continuous with no stops until finished.
3. The measuring distance is from the starting line to the nearest point where the body touches the ground.

VII COORDINATION

Baseball Throw for Distance

Equipment and facilities

1. Baseballs
2. Measuring Tape
3. Limestone
4. Field area 80-100 meters
5. Mark area by two lines five meters apart for the throwing area
6. Flags on sticks to place in the ground to mark the throw

Method

1. Throw the ball from within the throwing area.

2. Students are placed in groups of five and take turns throwing until they have completed three throws.

3. The overhand throw is used.

Scoring

1. The measurement is made from the starting line to the point of the greatest distance.

2. The score is recorded to the nearest half meter (Ex. 80.0 or 80.5).

Handball Throw

Equipment and facilities

1. Need a two meter circle with two lines on a 30^{o} angle from the center of the circle. Arcs within the throwing area are marked one meter apart starting at the 10 meter and continuing through the 50 meter arc.

2. Handball - size number two (48 centimeters)

3. Measuring tape

4. Small flags on sticks for marking the landing spot.

Method

1. Must throw the ball within the throwing area boundaries.

2. The thrower's feet must remain in the circle.

3. After throwing the ball the student must remain in the circle until excused.

4. The overhand throw is used.

5. Students are placed in groups of five and take turns throwing until they have completed three throws.

Scoring

1. The best result is recorded to the nearest half meter (EX. 80.0 or 80.5).

Rules

1. The test is not conducted during windy conditions.

VIII ACCURACY

Baseball Throw for Accuracy

Equipment and facilities

1. Baseballs
2. Measuring tape
3. Chalk
4. Limestone
5. Throwing target on a wall. Target size is 50x50 centimeters square. The target is placed one-half meter above the ground.
6. Target is 10 meters from the throwing point.

Method

1. Student stands in a circle before throwing at the target. The student uses the overhand throw.

2. Two practice trials are allowed.

3. The students are allowed ten throws for scoring.

Scoring

1. Each hit of the target is scored one point. The maximum score is ten.

Rules

1. Student must throw from the throwing circle.

Softball Throwing for Accuracy

Equipment and Facilities

1. Softballs
2. Measuring tape
3. Flat wall with a target that has 20, 30 and 40 centimeter circles.
4. The throwing circle is four meters from the target.

Method

1. The underhand throw is used.

2. Two practice trials are allowed.

3. Five throws are allowed for the test.

Scoring

1. Hits on the 20 cm areas are scored 3 points, the 30 cm area is 2 points, and the 40 cm area is scored 1 point.

2. Record the total score of the five throws.

IX SIZE OF BODY

Height

Equipment and facilities

1. Fixed wooden measuring stand.

Method

1. The student stands with relaxed shoulders and the feet at 60^{o} angle.

2. The inspector stands on the student's left side, helping the student acquire the correct posture.

3. Measures from the top of the head not the hair.

Scoring

1. Measure to the nearest centimeter.

Rules

1. The measuring is conducted at 10 AM.

Weight

Equipment and facilities

1. Spring weighing machine (scales)

Method

1. The student is weighed in shorts and without shoes.
2. The student should stand at the center of the weighing machine (scales).

Scoring

1. Measurements are taken in kilograms.

Rules

1. Adjust the scales to zero before using.
2. Students should step on the scales lightly and smooth.

Chest Girth

Equipment and facilities

1. Tape measure

Method

1. Measurement is taken around the body at the nipple level.
2. The measurements one taken two times. One when inhaling and one while exhaled.

Scoring

1. The two measurements are averaged for the score.

Rules

1. The tape measure should be tight for accurate measurement.

VITA

VITA

Chen-Hsing Huang was born on November 16, 1938 in Kaohsiung, Taiwan. Upon graduation from the Provincial Kaohsiung High School, he attended National Taiwan Normal University where he received a Bachelor of Education degree in Physical Education in 1962.

As a distinguished member of the teaching profession, he has taught high school for one year, junior college for three years, and university for thirteen years. Several honors were awarded to him for outstanding service as a teacher. Most notably, he twice earned the gold medal of physical education, awarded by the Ministry of Education, the Republic of China, in 1977 and 1980. Also, he received an award for "Most Excellent Physical Educationalist" by the Republic of China Amateur Athletic Federation, 1978. He has authored many research articles concerning comparative physical education and physical fitness which have been published in professional journals in Taiwan.

A latent interest in the sport of team handball took him to West Germany in 1977 where he graduated from the Freiburgy International Handball School. He later became a coach and official at the international level in the sport of team handball. As head coach of the Taiwanese National Youth Team, he guided Taiwan to four consecutive

world titles. In addition, he was recognized as "Most Excellent Referee" by the Republic of China Amateur Athletic Federation in 1979. For the past ten years, he has acted as Chief of Research and Development of the Republic of China Handball Association, a position he presently assumes. Recently, he authored a Chinese book entitled Theory and Practice in German Handball.

Chen-Hsing arrived at Eastern Illinois University in August, 1980, as a member of the faculty exchange program between Eastern and Kaohsiung Teachers College, Taiwan. At Eastern, he completed studies for the Master of Science degree in Physical Education in May, 1981. During his stay at Eastern, he developed and coached the Eastern Illinois University Team Handball squad which participated in the Chung Jeng World Cup Tournament in Taipei, Taiwan from April 25 to May 1, 1981. The team won two games and placed a respectable fourth in the six team tournament. The team also won a game played against Kaohsiung College, the team he normally coaches.

He has a wife and two children living in Taiwan. He will return to Taiwan in August, 1981, to resume his duties as professor of Physical Education at Kaohsiung Teachers College.